The athletes elbow

Rahusen, Frank Theodoor Gabriel

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The Athletes Elbow

Frank Th.G. Rahusen

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Frank Theodoor Gabriël Rahusen
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Promotor:	Prof. dr. R.L. Diercks
Copromotor:	Dr. D. Eygendaal
Beoordelingscommissie:	Prof. dr. L.C. Almekinders Prof. dr. F.J.G. Bakxs Prof. dr. M. Maas

Paranimfen: Dr. J.A. van Essen
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The Athletes Elbow

Frank Th. G. Rahusen

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Promovendus	Drs. F. Th. G. Rahusen
Promotor	Prof. Dr. R. Diercks
Copromotor	Dr. D. Eygendaal

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Chapter 1

Introduction and aim of this thesis

a. Basic anatomy and biomechanics of the elbow joint.
b. Common injuries of the elbow in athletes.
c. Aim of this thesis and outline of the chapters.

a. Basic anatomy of the elbow joint.

Overhead athletic sports are becoming more and more popular. This is why the incidence of injuries to the elbow in athletes of all age groups increases.

The elbow joint is one of the most complex joints in the human body. To understand the pathology behind the injuries around the athletes elbow, a thorough understanding of the basic anatomy and the biomechanics is necessary. The elbow functions as a link between the shoulder and the wrist. Because of the elbow, the hand can be positioned in space. By this the arm can function as a fulcrum for the forearm and hereby it will create a grasping function for the hand. Impairment of the function of the elbow will result in a decrease in arm function and thus in daily activities and especially overhead athletic activities. Primary stability is the result of the exact fit between the olecranon and humerus in extension and a complex articulation of the coronoid and the distal humerus in flexion. The part in which the bony structures contribute the most in stability is in less than 20 degrees of extension and more than 120 degrees of flexion[1]. Between 20 degrees and 120 degrees of flexion the primary restraints to stability are the soft tissues. The bony parts of the elbow consist of the humerus, the olecranon and the radius and these three bones together form three articulations; the ulno-humeral joint, the radio-humeral joint and proximal radio-ulnar joint[2]. The elbow joint articulation is classified as a trochoginglymoid joint. The radio-humeral and proximal radio-ulnar joint allows axial rotation (trochoid) type of motion. The ulno-humeral joint resembles a hinge (ginglymus), allowing flexion and extension. Range of motion of the elbow is an average of 150 degrees of flexion and 0 to -5 degrees of extension. Average pronation and supination are 75 and resp. 70 degrees. For most activities in a normal daily life 100 degrees of elbow motion are needed. This is the so called 'functional arc of motion[3].

During overhead activities, athletes are pushing their elbow continuously to the limits of the range of motion of the joint. This extremes in ROM in combination with the tremendous forces generated along the elbow during athletic activities, forms the basic mechanism behind sports related injuries of the elbow joint.

The most important soft tissue stabilizers around the elbow are the medial and lateral collateral ligaments. The ligaments actually are more or less thickenings of the capsule. The medial collateral ligament or MCL consists of three parts; the transverse part, anterior part (AMCL) and the posterior part (PMCL). The function of the transverse ligament is unclear and its contribution to the stability is debated, as it runs from the ulna to the ulna. The most important restraint to valgus instability is the anterior bundle of the MCL. The AMCL consists of an anterior and a posterior bundle, which are tightened during flexion and extension in a reciprocal way. Unlike the medial collateral ligament complex, with its rather consistent pattern, the lateral ligaments of the elbow joint are less discrete, and individual variation is common. It usually consistst of 4 main structures; the radial collateral ligament or RCL, the lateral ulnar collateral ligament or LUCL, the annular ligament or AL and the accessory lateral collateral ligament or ALCL[4]. Morrey's investigation has suggested that several components make up the lateral ligament complex[3]. The current thinking is to consider the complex to be roughly in the shape "Y". They attach to the anterior and posterior aspect of the semilunar notch of the elbow[5,6]. Also the capsule of the elbow contributes to stability. The anterior structure is taut in extension and becomes lax in flexion. The capsule is normally a thin transparent structure. Significant strength is provided by transverse and obliquely directed fibrous bands. Also the muscle action around the elbow contributes to stability. This is the so called active or dynamic stability.

Biomechanics of the elbow joint.

Most activities of daily living can be accomplished with 100° of elbow flexion (30°/130°) and 100° of forearm rotation (50°/50°)[7]. Movement in both directions is limited by the geometry of the joint surfaces, surrounding bones, capsules, ligaments, and muscles. As a result of congruous articular surfaces and soft tissue constraints, the elbow is one of the most stable joints of the musculoskeletal system. As described before, flexion and extension range from 150 degrees to -5 degrees. The average range of flexion and extension of subjects between 1 and 19 years old was 145.4 to 0.8° and 140.5° to 0.3° for those who were between 20 and 54 years of age[8]. Comparison of the ranges of motion, measured with a full circle goniometer, of the right elbow and left elbow in right hand dominant people showed passive flexion-extension of 142.8° to -3.8° for the right elbow and 145.6° to -6.0° for the left elbow[9]. An explanation for the difference in range of motion is that the soft tissues around the elbow of the dominant arm are more contract and thus leading to a slight diminished range of motion. Eliminating each element sequentially while recording displacement can show the relative contribution of each stabilising structure. The complementary shape of the articular surface form the primary bony elbow stability in the entire range of motion, but this contribution is largest in extension. The physiological collateral laxity of normal elbows is approximately 5 degrees[10]. Constraints to elbow instability can be static, such as the constraints the bones and ligaments provide or dynamic provided by muscles acting on the stability as the elbow moves. The relative role of the osseous and soft tissue restraints are shown in tables I and II[11,12].

It still remains unclear to what extent these structures limit the range of motion. Progressive excision of the proximal ulnar articular tip results in stepwise decrease

Table I: Relative contribution to resist valgus stress (%)[27]

	Extended	90° elbow flexion
MCL	31	54
Soft tissue, capsule	38	10
Osseus, articulation	31	33

Table II: Relative contribution to resist varus stress (%)[27]

	Extended	90° elbow flexion
LCL	14	9
Soft tissue, capsule	32	13
Osseus, articulation	55	75

in stability of the elbow joint. Guttierez has emphasised the role of the AMCL in limiting extension[13]. The arc of flexion of a cadaveric elbow increases from 150° to 190° after all muscles have been removed. With cutting all ligaments it increases up to 210°. Except at the extremes of flexion and extension the ulno-humeral joint could be assumed to move as a uniaxial articulation; the axis of rotation in flexion and extension is through the centre of the trochlea, colinear with the distal anterior cortex of the humerus. The transverse axis of rotation of the radiohumeral joint coincides with the ulno-humeral axis, the longitudinal axis passes through the radial head proximally and the ulnar head distally[12,13,14]. The carrying angle (angle between the long axis of the humerus and the long ulnar axis) varies in different angles of flexion and can be defined as a function of anatomic variations of the obliquity of the articulations during movement. Morrey and Chao found that the carrying angle varied from 11° of valgus with the elbow in full extension to 6° of varus in full flexion[14]. This angle changed in a linear fashion during flexion, the pattern of change being independent of forearm position (neutral, supination or pronation). (See Figure 1)

During flexion and extension the ulna rotates axially on the humerus. Internal rotation of 5° of the forearm occurs near the beginning and external axial rotation of 5° toward the end of flexion[14]. (See Figure 2)

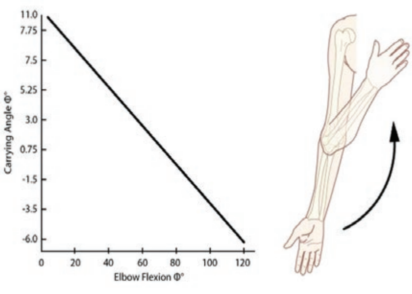

Figure 1.

The change in carrying angle of the forearm during elbow flexion is linear, progressing from a valgus (+) to a varus (-) angle.

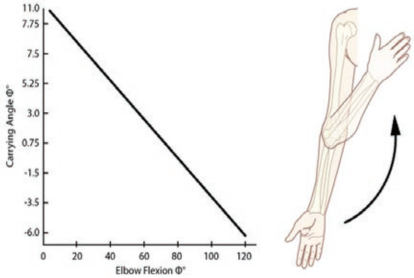

Figure 2.

Axial rotation about the long axis of the forearm taken as a unit during elbow flexion is internal until about 80° of flexion and external thereafter.

(figure 1 and 2 from BF Morrey and EYS Chao; Passive motion of the elbow joint)

Valgus stress is in large extent (80%) resisted by the proximal portion of the greater sigmoid notch, whereas the distal portion of the joint surface (65%) primarily resists varus stress[15.] An and Morrey showed the olecranon to contribute to valgus stability in full extension, but at 90° flexion the resistance to valgus stress is largely a function of the MCL integrity. With sequential removal of portions of the olecranon, the MCL complex is also sequentially removed which contributes to the resulting instability demonstrated in a linear fashion[16]. The radiohumeral articulation provides valgus stress resistance as a secondary constraint to compressive loads across the joint and inhibits posterior migration or dislocation at 90° flexion[13]. Recently the radial head was described to have stabilising capacities in forced varus and external rotation as well[17]. Isolated excision of the radial head causes slight varus and external rotational instability of 4.8° and 10.4° respectively in 40° flexion[18]. Studies of Morrey et al. have shown an intact elbow under gravity valgus stress to have a peak mean of 5° abduction, which typically occurred between 10° and 20° flexion, and internal rotation of the ulna of 2.8°between 20° and 40° flexion. Isolated release of AMCL and PMCL causes increases in abduction of about 6°-8° and internal axial rotation of the ulna of approximately 9°. Removal of the radial head or PMCL demonstrated no alteration in abduction; release of both radial head and MCL showed gross instability and marked displacement and subluxation in 120° flexion.

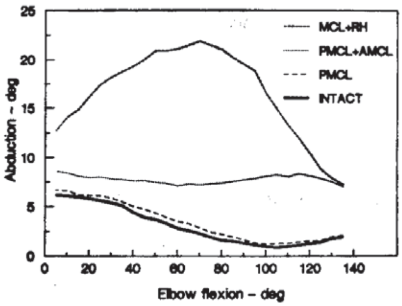

Figure 3.

Release of MCL shows minimal-moderate abduction displacement when the posterior-anterior bundle is first removed. When the radial head is removed additional displacement occurs.

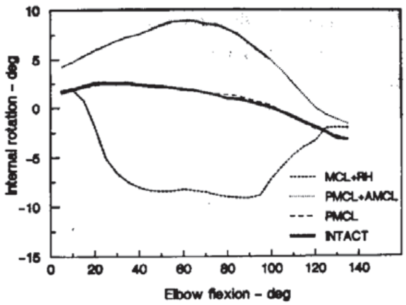

Figure 4

This shows the same effect on internal rotation. MCL = medial collateral ligament, RH = radial head, PMCL= posterior medial collateral ligament, AMCL = anterior medial collateral ligament.

(from BF Morrey, S Tanaka and KN An: Valgus stability of the elbow. Clin Orth Rel Res 265;187,1991)

The varus stability is rather unaffected by the medial transections during tests[7,16]. Söjbjerg et al. used potentiometers to measure rotatory angulations during a constant valgus-varus moment of 1.5 Nm during elbow flexion between 0° and 140°[18]. His data showed the same instability pattern as Morrey et al.; an increase of valgus and internal rotational instability was demonstrated after cutting the AMCL of a maximum of respectively 11.8° and 5.4 with 70° of flexion. Further cutting of the PMCL and the medial capsule increased valgus instability and internal rotational instability to a mean maximum of -24.2°/19.6°[19,20].

In conclusion, the AMCL can be said to be the primary constraint to valgus and internal rotatory forces on the medial side of the elbow, the PMCL is the secondary constraint and the radial head is the tertiary constraint. In contrast to the general agreement in the literature on stabilisers at the medial side, descriptions of both anatomy and function of collateral ligament complex at the lateral side of the elbow have varied considerably in the past[21-27]. Varus stress is constrained in extension equally by the joint articulation (55%) and lateral collateral ligament[7]. O'Driscoll et al. reported the lateral ulnar collateral ligament (LUCL) to contribute significantly to both rotational and varus stability of the elbow joint[21-24]. The LUCL was observed to prevent the so-called posterolateral elbow joint instability, demonstrated by the pivot-shift test of the elbow. However Olsen et al. showed the radial collateral ligament (RCL) to be an important stabiliser of the ulno-humeral joint in forced varus, external rotation and pivot shift test and they showed that the annular ligament and LUCL is a secondary constraint[25-27].This might be explained by the use of different definitions of the anatomy of the soft-tissue constraints on the lateral side in both studies. Recently Seki et al. have described a 'Y-concept' of the lateral ligaments of the elbow in order to define primary and secondary constraints[28].

b. Common elbow injuries in athletes.

Because of the increasing popularity of sports, elbow injuries are seen more frequently[29]. Although still very rare, undetected elbow injuries can lead to disability and time consuming diagnostic examinations. If primarily seen by an specialist (sports physician, orthopaedic surgeon) in the field of the elbow, this time delay can be diminished. Especially the sports with extensive overhead arm activity can lead to overuse syndromes around the elbow. Common tendinopathies around the elbow are **medial and lateral epicondylitis**; 5% of normal population will develop an epicondylitis during his or her life, whereas in professional tennis players up to 50% will suffer from epicondylitis during his or her career. Lateral epicondylitis is 10 times more frequent than medial epicondylitis. In both medial and lateral epicondylitis, chronic repetitive microtrauma plays a role. In medial and lateral epicondylitis extrinsic tensile overload exists of the attachment of the tendon. Eventually the tensile forces will lead to micro ruptures of the bone tendon site which will not heal spontaneously. Tennis is related to lateral epicondylitis, golf is associated with medial epicondylitis. Both conditions are also often seen in a variety of other sports for example javelin throwing, badminton, squash, racquetball and bowling. Clinical findings are tenderness at the insertion point at the lateral or medial epicondyle. Pain in resisting forced pronation (medial epicondylitis) or extension (lateral epicondylitis) of the wrist is one of the key features found at physical examination. Plain X-rays are used to rule out other associated pathology. Sometimes calcifications can be seen at the origin of ECRB (extensor carpi radialis brevis) point. With ultrasound, tendinosis can be found and even partial or full thickness tears can be seen. An MRI usually is, in general, not necessary, but can rule out other pathologies especially intra-articular findings. Lateral epicondylitis, as mentioned earlier, is a much more encountered entity. 50% of all athletes involved in sports with extensive overhead arm action have symptoms of lateral epicondylitis[30]. It is the most encountered tendinopathy around the elbow. Pathologic changes are seen at the common extensor tendon insertion at the lateral epicondyl. It is comparable to the pathology that is seen in medial epicondylitis. Histology reveals a mucoid degeneration of the extensor origin. Physical examination commonly reveals tenderness at the lateral epicondyl. Resisting extension of the wrist with the elbow fully extended is one of the most seen signs at clinical investigation.

As in medial epicondylitis, lateral epicondylitis is best treated conservatively. If an extensive program of conservative measurements during 6 months to 1 year fails to resolve the complaint, operative intervention can be an option. Common approaches are the open technique for both entities. Also the arthroscopic approach is becoming more and more popular. The advantage of an arthroscopic procedure is the visualization and treatment of associated intra-articular pathologies as synovial fringes, chondral damage or loose bodies.

Osteochondritis dissecans and **posterior impingement** are thought to develop because of repetitive overhead throwing actions. This will produce repetitive compression at the bony structures and repetitive tensile forces on the ligamentous and capsular structures. Excessive valgus stress can lead to posteromedial impingement of the olecranon into the posterior fossa of the humerus leading to symptoms as pain, osteophyt formation and eventually sometimes even loose bodies. In general the treatment of posteromedial impingement is conservative. If this does not alleviate symptoms arthroscopic debridement can be an alternative. It is of the utmost importance that the stability of the elbow is assessed. If there is any MCL instability, simple debridement will only shortly alleviate symptoms. Sometimes a combined procedure with MCL reconstruction is necessary. In case of severe valgus instability, the increased compressive forces along the radiohumeral joint can finally result in subsequent damage. This can lead to osteochondritis dissecans at the capitellum and/or radial head. In the juvenile athletes a condition known as Panner's disease is seen seldom. The etiology is unclear, but it probably relates to vascular incidents at the capitellum, in combination with repetitive microtrauma, leading to bone necrosis and sometimes loose bodies. If the overlying cartilage remains intact treatment consists of limiting sports activities and rest. If there is fragmentation of the OCD with loose bodies or loose chondral flaps, arthroscopic debridement is indicated. Other pathologies around the athletes elbow are the **ligamentous injuries**. The most affected ligament is the medial collateral ligament. The MCL is often ruptured after hypervalgus or hyperextension injuries, or after a postero-lateral dislocation of the elbow. Traumatic injuries of the MCL related to fractures around the elbow, are beyond the scope of this thesis and are not discussed any further. The **chronic MCL insufficiency** is frequently seen in the overhead throwing athletes. Because of the chronic valgus extension overload the MCL is stressed with every throw. The MCL, mainly the anterior bundle, is the primary restraint to valgus with the elbow range of motion between 20 and 120 degrees. During the overhead throwing motion, valgus stress on the medial elbow occurs during the cocking and acceleration phases of throwing. From late cocking to ball release, the elbow rapidly extends from approximately 125° to 25° at ball release at an average angular velocity of 2.300° per second[31]. High tensile forces are concentrated on the medial side of the elbow, estimated at nearly 290 N[32]. This will result in tremendous tensile forces on the medial side of the elbow. These tremendous forces account for the high number of MCL injuries in overhead athletes. **Injury of the LCL complex** is rare, and in most cases not sports related but trauma related. Varus stress during sports is very rare, especially repetitive stress. It usually occurs during acute elbow trauma as in a acute fall resulting in an elbow dislocation or dislocation with acute spontaneous relocation. Also over enthusiastic surgery of a tennis elbow can lead to varus instability of the elbow. Posterolateral rotatory instability is thought to be a part of the chronic or recurrent elbow dislocation in posterolateral direction. Symptoms are catching at the lateral side of the elbow. However, most elbow dislocations finally result in a stable elbow and do not go on to a PLRI (=posterolateral rotator instability). This can be attributed to the fact that the healing potential of the lateral ligament complex is high after injury. Treatment of PLRI can be conservative for a short period but requires an LCL reconstruction with a tendon graft in most cases.

c. Aim of this thesis and outline of the chapters.

The aim of this thesis is to create insight in the most common sports related injuries around the elbow. For an adequate treatment a thorough understanding of the anatomy and the biomechanics is mandatory, this is given in **chapter 1**. The most common injuries are addressed in the different chapters and treatment options and results after treatment are given. **Chapter 2** gives insight in the biomechanics in tennis players and the different, tennis related, injuries are delineated. **Chapter 3** will give insight in treatment of muscle injuries. Common treatment of muscle injuries is by R.I.C.E. principal (rest-ice-compression-elevation). Non-steroidal anti-inflammatory drugs are frequently used to treat muscle injuries in athletes. It is not known whether the anti-inflammatory effects of these drugs are important or whether their effectiveness is a result of their central analgesic effect. **Chapter 4** will describe the authors preferred method for intra-articular injections into the elbow joint. The elbow is among the most common joints that are aspirated and/or injected. An intra-articular approach should be a convenient and a safe procedure with minimal risk of complications. Several approaches to access the elbow joint have been outlined in literature, but a comparative study between the well known classic lateral approach and the newer transtriceps approach was lacking. **Chapter 5** will give a general overview on arthroscopy of the elbow. The indications, portal positions and common complications are described. In **chapter 6** the arthroscopic treatment of posterior impingement is highlighted. The purpose of this study was to evaluate the effectiveness of arthroscopic treatment of posterior impingement in the athletes elbow. In **chapter 7** we conclude that an arthroscopic debridement of an osteochondritis dissecans (OCD) of the radial head and or capitellum is a good treatment option in the overhead athlete. The clinical outcome in this series after arthroscopic debridement for OD of the elbow shows that it provides excellent pain relief during ADL and sportive activities. In **chapter 8** the medium term results are shown after MCL reconstruction of the elbow in European athletes with interference screw technique and triceps fascia autograft. Last decades there is an increasing interest in Medial ulnar Collateral Ligament (MCL) reconstruction techniques for MUCL insufficiency of the elbow. All case series are based on American and Asian Athletes and use primarily a palmaris longus tendon or gracilis tendon as an autograft in reconstructions. In this new technique an interference screw fixation is combined with triceps fascia autograft. However, the dropout, even after successful reconstruction, in European athletes is high.

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Chapter 2

Biomechanics of the elbow joint in tennis players; relation to pathology.

Eygendaal D, Rahusen FT, Diercks RL.

Br J Sports Med. 2007 Nov; 41(11):820-3.

Abstract

Elbow injuries constitute a sizeable percentage of tennis injuries. A basic understanding of biomechanics of tennis and analysis of the forces, loads and motions of the elbow during tennis will improve the understanding of the pathophysiology of these injuries. All different strokes in tennis have a different repetitive biomechanical nature that can result in tennis-related injuries. In this article, a biomechanically-based evaluation of tennis strokes is presented. This overview includes all tennis-related pathologies of the elbow joint, whereby the possible relation of biomechanics to pathology is analyzed, followed by treatment recommendations.

Introduction

The increase in the number of participants in sports as baseball, tennis, American football and volleyball has resulted in a sharp rise of sports injuries and thus to an increased incidence of elbow injuries in recent decades. In the Netherlands, a study was conducted amongst all patients that received treatment at the emergency ward of general hospitals between 1998-2001; the injury risk was calculated for different group of patients in relation to type of racquet sport, age and sex. In tennis the injury risk was fairly similar for males and females; the older age groups were affected more often and indoor tennis was related to a higher incidence of injuries in comparison to outdoor tennis[1]. The magnitude of forces across the elbow during tennis strokes can produce tremendous valgus and extension overload in players. The game of tennis has been described as a power game because of the high ball velocities and the explosive physical action of the players[2]. Biomechanical analysis of these forces, loads and motion on the elbow in tennis will lead to an improved understanding of the pathophysiology of injuries in tennis. Common injuries encountered include ulnar collateral ligament (UCL) tears, flexor-pronator muscle tendinosis or tears, ulnar neuritis, posterior impingement, ostechondritis dissecans of the capitellum and tendinopathy of the extensors, whereby the tendinopathy probably has the highest prevalence in tennis players. The purpose of this article is to give an overview of elbow injuries and their treatment in adult tennis players in relation to the current knowledge regarding biomechanics of the elbow in tennis.

Biomechanics of the elbow in tennis

In the normal elbow joint, stability is maintained by the combination of joint congruity, capsuloligamentous integrity and well balanced intact muscles. The olecranon and olecranon fossa joint provide primary stability at less than 20° or more than 120° of elbow flexion. In between stability is provided by soft tissue constraints, mainly the UCL[3,4]. The kinetic chain of the tennis service starts with the feet and knees and travels through legs, trunk/back and shoulder to the elbow joint and finally through the wrist and hand. Biomechanically, the elbow functions primarily as a link in this kinetic chain, allowing transfer of kinetic energy from the body to the racquet. High-speed video analysis studies from Kibler et al[5] have demonstrated that during the service the elbow moves from 116° to 20° of flexion within 0.21 s, with ball impact occurring at approximately 35° of flexion. During ground strokes, observed flexion and extension range was much less averaging 11(46-35)° of flexion on the forehand and 18(48-30)° in the backhand. The calculated angular velocity during the service motion was 982°/s for elbow extension[5]. These data reveal the extreme forces that the elbow must repetitiously absorb during tennis strokes in flexion and extension direction. In most sports with overhead movement, including tennis, an increased external rotation of the shoulder develops at the cost of internal rotation. Elliot has stressed the important role of internal rotation of the upper arm at the shoulder during service and forehand strokes[6]. This demand on internal rotation of the upper arm during tennis can result in an increase of internal rotatory forces across the elbow joint. In the third plane, valgus and varus, we also can observe abnormal load transfer in tennis. During normal elbow motion the axis of the elbow is from varus into valgus as it moves from flexion to extension[3]. This combination of valgus forces and rapid extension during tennis results in tensile forces along the medial side, compression on the lateral portion of the elbow and shear forces in the posterior compartment. This combination is often called "valgus extension overload" syndrome in overhead athletes and can play a role in some injuries in the elbow in tennis players[7,8]. In summary, the tennis stroke puts very high loads on the elbow joint in extension, internal rotation and valgus, and this occurs in repetitive movements at very high speeds with very high forces.

Insufficiency of the UCL

The UCL complex consists of an anterior oblique ligament (AOL), posterior oblique ligament (POL) and a transverse band. The AOL has been shown to be the most important soft-tissue constraint to valgus instability of the elbow and is the strongest and stiffest of the collateral ligaments of the elbow with an average failure load of 260 N. The AOL is also the primary stabilizer to internal rotatory forces[3,4]. The flexor carpi ulnaris muscle, pronator teres and flexor digitorum superficialis form predominantly the musculo-tendinous unit overlying the AOL; all three muscles have been described to contribute to medial support as secondary stabilizers. Acute rupture and chronic overload of the UCL has been described extensively in athletes, especially in baseball pitchers[8–12]. Findings in acute medial collateral ligament injury are moderate to severe elbow pain, acute onset of pain during service or a popping sensation followed by medial ecchymosis or even acute ulnar nerve symptoms. Chronic overuse of the elbow, as described before, can also result in progressive attenuation of the UCL leading to ligamentous insufficiency even in the absence of a singular catastrophic episode of ligament failure. At physical examination the instability can be revealed; the degree of laxity is often underestimated. In patients with insufficiency of the UCL a typical painful arc can be produced using the "milking manoeuvre"[12]. The diagnosis is confirmed by positive elbow MRI, dynamic stress radiographs, dynamic ultrasonography or positive valgus test at anaesthesia. Treatment can be conservative or surgical[13]. The previous described valgus and internal rotatory forces result in micro trauma of the UCL and eventually attenuation of the ligament. Attenuation of UCL leads to abnormal valgus movement of the elbow joint affecting the mechanics of the highly constrained articulation of the posterior elbow. This results in bony impingement at the superomedial corner or the olecranon and the corresponding fossa. Such impingement can lead to chondral lesion and eventually reactive changes such as osteophytic spur formation[14,15]. In prevention and treatment of UCL insufficiency in tennis players, therapy should be based on the above-mentioned biomechanics overload in all three planes of movement, extension, rotation and valgus.

The "axis of internal rotation" of the humerus should be addressed, with optimal internal rotation of the shoulder, in combination with a proper technique of ground strokes and service in which the extension should be monitored carefully. The flexor carp ulnaris muscle, pronator terse and flexor digit rum superficialis have been described to contribute to medial stability as secondary stabilizers. Specific training should be structured to these muscles to enhance valgus stability of the elbow joint[16].

Flexor-pronator tendinosis or rupture

Unlike to the common "tennis elbow", or lateral epicondylitis, this tendinosis is more common in high-level tennis players than it is in recreational players. The pronator teres and flexor carpi radialis have been identified as the most common sites of pathologic changes[17,18]. Athletes complain about tenderness distal and lateral to the medial epicondyl; resisted wrist flexion and forearm pronation exacerbate pain. Treatment is in general a non-operative program for at least 6 months; persistent symptoms after 6 months can be an indication for surgical treatment after exclusion of any other pathologic causes, especially UCL insufficiency. Medial epicondylitis represents an "absolute overload" of normal anatomy and physiology due to supra normal forces; possible related factors are an excessive wrist snap, "open stance hitting", opening too soon on serve and short arming of the strokes[5]. More research needs to be performed to clarify the relation of biomechanics in tennis and flexor-pronator tendinosis.

Ulnar neuritis

The cause of ulnar neuritis in the cubital tunnel is considered to be the result of mechanical stimuli on the ulnar nerve in the cubital tunnel. Ulnar neuritis around the elbow can be the result of compression or traction from valgus stress and can be seen as an isolated injury or in combination with UCL insufficiency or chronic flexor pronator mass tendinosis. Compression can occur due to a tight cubital tunnel, osteophytes from the ulno-humeral joint, muscle hypertrophy or subluxation of the nerve. In tennis players, the initial presentation of ulnar neuritis can be pain along the medial joint line associated with dysesthesias, paresthesias or even anaesthesia in the small and ulnar half of the ring finger. The degree of sensory and motor changes can vary depending on the severity and duration of ulnar nerve compression. Surgical intervention is indicated in case of progressive muscle weakness, persistent muscle weakness for more than 4 months, chronic neuropathy or failure of a non-surgical regime[19,20]. In a cadaver study, the movement of the ulnar nerve at the proximal aspect of the cubital tunnel was significantly increased during all throwing phases with increased elbow flexion ($p<0.05$). A mean (SD) maximum movement of 12.4 (2.4) mm was recorded during the wind-up phase with maximum elbow flexion. The maximum strain on the ulnar nerve during the acceleration phase was found to be close to the elastic and circulatory limits of the nerve[21]. Although in this study the "throwing motion" of the elbow was studied, the same principles can probably be applied to motion of the elbow during service. The ulnar nerve is subjected to longitudinal strain in the cubital tunnel during the service motion and this longitudinal strain is increased as the elbow is in greater flexion. During rehabilitation of ulnar neuritis the amount of flexion during service should be taken into account. As ulnar neuritis can be the result of valgus instability or insufficiency of the UCL the same principles should be applied as described under UCL insufficiency.

Posterior impingement

Posterior impingement of the elbow is an uncommon disorder in the general population; it is mainly seen in patients that overuse their elbow during specific sporting activities as such overhead throwing or tennis[22,23]. The lesion is due to repetitive combined hyperextension, valgus and suspiration of the elbow resulting in a mechanical abutment of bony or soft tissues in the posterior fossa of the elbow. Posterior impingement can also be associated with ligamentous instability of the elbow, especially UCL insufficiency. In a cadaver study, valgus torques of 1.25 and 2.0 Nm were applied and kinematic data were obtained with intact and transected UCL at different angles of flexion angle using a 3-dimensional digitiser. For a given load and flexion angle, the contact area decreased and the pressure increased with increasing medial ulnar collateral ligament insufficiency. The conclusion was that medial ulnar collateral ligament insufficiency alters contact area and pressure between the posteromedial trochlea and olecranon and helps explain the development of posteromedial osteophytes in cases of UCL insufficiency[24]. The athlete complains of pain posteriorly, joint effusion, locking, crepitus and a decrease in range of motion, most notably an extension deficit. If conservative treatment of posterior impingement is not successful, arthroscopic debridement of the elbow with removal of osteophytes and synovectomy can be used in these patients. In the treatment of posterior impingement, hyperextension of the elbow joint and insufficiency of UCL must be addressed.

Osteochondritis dissecans

Osteochondritis dissecans (OD) of the elbow is an uncommon disorder in the general population. It is usually seen in patients that overuse their elbow during specific sporting activities in which the elbow is extended forcefully or axially loaded[25]. It has been described in players with insufficiency of the UCL or players with muscle weakness or hyperlaxity of the elbow joints. This injury occurs usually in the lateral compartment as a result of shear and compression forces to the particular cartilage or underlying bone of the lateral compartment. These compressive forces on the radio-humeral joint can become as high as 500 N, resulting in (Osseo) chondral fractures and secondary defects in the radio humeral joint[26]. Tennis players mostly complain on a dull and aching pain in and around the elbow shortly after demanding activities. Findings during physical examination as swelling, tenderness over the radiohumeral joint and limitations in motion; especially loss of extension is either seen. Treatment is dependent of the severity, size and location of the lesion and age of onset and can be conservative or surgical. Underlying valgus instability should be addressed accordingly and hyperextension should be avoided.

Lateral epicondylitis

Lateral epicondylitis is 7-20 times more common than its medial counterpart and produces pain along the lateral elbow and forearm. Treatment is generally conservative. In cases lasting more than a year, surgery can be considered. Lateral humeral epicondylitis is a condition that primarily occurs in the recreational tennis player. One of the reasons is an increase of wrist extension in more experienced players just prior to ball impact. Novice players strike the ball with their wrist in more flexed position at impact[27]. Observations of the patterns of activation and joint kinematics of novice tennis and advanced payers, using kinematic data in conjunction with a computer model, have revealed substantial eccentric contractions of the extensor carpi, which are likely the cause of repetitive microtrauma leading to tennis elbow injuries. Adopting the technique seen in advanced players probably helps limit the eccentric contractions and reduces the likelihood of injury[28]. Tennis grip size was believed to play a crucial role in the past. However, based on fine-wire electromyography studies in which muscle activity in extensor carpi radialis longus and brevis, extensor digitorum communis, flexor carpi radialis and pronator teres were measured, tennis racquet grip size (1/4) above or below Nirschl's recommended measurement does not significantly affect forearm muscle firing patterns[29]. Alterations in tennis racquet grip size do not have a significant effect on forearm muscle activity and therefore might not represent a significant risk factor for lateral epicondylitis. The unusual EMG findings of increased activity in injured muscles can be explained by faulty mechanics that predispose to the development of tennis elbow. It is therefore clear that concentric and eccentric training should be performed for the forearm muscle, as muscle imbalances will lead to injury in lateral epicondylitis.

What is already known on this topic

- The biomechanics of tennis have been well documented.
- The clinical symptoms of tennis-related injuries and their treatment have been published over a wide range of journals.

What this study adds

- The most important biomechanical aspects of tennis in relation to the treatment of the tennis-related injuries are described.

Conclusions

Tennis places the ligamentous, osseous, musculotendinous and neural structures of the elbow at increased risk for various injuries. Proper training and preventive exercise, based on sound biomechanical research, can result in decrease of loads across the elbow in tennis players. It is important to recognize that injuries can occur simultaneously and that every entity must be treated accordingly. The kinetic chain of the tennis service and strokes should be taken into account. For example tennis players with more effective knee flexion-extension during the service action were associated with lower loading at the shoulder and elbow.30 The exact impact of this finding is as yet unknown and needs to be further investigated.5 Internal rotation of the upper arm at the shoulder during the service and forehand is of utmost importance; decrease of internal rotation in the shoulder can increase rotatory stress on the elbow. Internal rotation of the upper arm and pronation of the forearm during the early phase of the follow-through of the service probably reduce these forces on the elbow.2 Grip size does not seem to play a role in elbow injuries; playing with a "Western grip" can possibly increase valgus stress on the elbow, especially during acceleration.2 Strengthening the forearm flexor muscles and reducing elbow extension after impact might help reduce injury risk. In general, most symptomatic conditions of the elbow in tennis players can be treated conservatively initially. In cases where conservative treatment is not successful, surgical intervention is indicated. In conservative and surgical treatment protocol analysis of the biomechanics of each tennis player must be performed and abnormalities addressed.

Abbreviations

AOL = anterior oblique ligament
OD = osteochondritis dissecans
POL = posterior oblique ligament
UCL = ulnar collateral ligament

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Chapter 3

Nonsteroidal Anti-inflammatory Drugs and Acetaminophen in the Treatment of an Acute Muscle Injury.

Rahusen FT, Weinhold PS, Almekinders LC.

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Abstract

Background: Nonsteroidal anti-inflammatory drugs are frequently used to treat muscle injuries in athletes. It is not known whether the anti-inflammatory effects of these drugs are important or whether their effectiveness is a result of their central analgesic effect.

Hypothesis: The effects of nonsteroidal anti-inflammatory drugs are no different than the effects of an analgesic (acetaminophen) without anti-inflammatory action in an experimental, acute muscle contusion model.

Study Design: Controlled animal study.

Methods: A standardized, unilateral, nonpenetrating injury was created to the tibialis anterior muscle of 96 adult male mice. Four treatment groups were used: group 1, placebo treatment; group 2, treatment with rofecoxib, a nonsteroidal anti-inflammatory drug with cyclooxygenase-2 selectivity, and treatment after the injury; group 3, rofecoxib treatment starting 24 hours before the injury; and group 4, acetaminophen treatment after the injury. The muscle and the contralateral normal muscle were evaluated at 2, 5, and 7 days after injury by grading of gait, wet weight as a measure of edema, and histologic evaluation.

Results: Group 1 had significantly more gait disturbances at day 2 than all other groups ($P < .05$). No differences were found at days 5 and 7. Wet weights showed an increase at day 2 in group 1 ($P < .01$). Again, no differences were found at days 5 and 7. Histology revealed similar inflammatory changes at day 2 in all groups, with regeneration of muscle fibers at days 5 and 7.

Conclusions: The results indicate that rofecoxib as a nonsteroidal anti-inflammatory drug and acetaminophen as a non-nonsteroidal anti-inflammatory drug analgesic have similar effects. The lack of differences in wet weights and histology suggests that the anti-inflammatory effects of rofecoxib are not an important feature of its action.

Clinical Relevance: The routine use of nonsteroidal anti-inflammatory drugs in muscle injuries may need to be critically evaluated because low-cost and low-risk analgesics may be just as effective.

Keywords:

- muscle injury
- nonsteroidal anti-inflammatory drug (NSAID)
- acetaminophen
- soft tissue
- contusion

Muscle injuries are among the most common injuries seen in primary care, occupational health, and sports medicine[4]. The most common muscle injuries are those caused by excessive stretch on the muscle-tendon unit and those caused by blunt-force trauma[6]. Blunt-force muscle trauma is frequently seen in contact sports in which opposing players cause a muscle contusion by direct impact on the muscle belly. This can produce significant disability because of pain and impaired muscle function. The ideal treatment for these muscle contusions remains uncertain. Use of nonsteroidal anti-inflammatory drugs (NSAIDs) is frequently advocated[12] because animal studies have shown a marked inflammatory response to an experimental contusion injury[10]. On one hand, NSAIDs may decrease the inflammatory response and thereby the pain and swelling[1–3]; on the other hand, it is possible that the inflammatory response is a necessary phase during soft tissue healing[11]. Inhibition of this phase could result in poor healing as has been shown with potent anti-inflammatory agents such as corticosteroids[5]. Another potential concern of NSAID use in muscle injuries is their direct effect on satellite cells. Satellite cells are responsible for the regenerative response after loss of muscle fibers by transforming into myoblasts. The only study that directly examined this was unable to find a direct effect of NSAIDs on satellite cell proliferation[15]. Finally, it is possible that oral NSAIDs are actually incapable of affecting the peripheral inflammatory response. The site of action of NSAIDs is the inhibition of cyclooxygenase (COX), the enzyme that controls the production of prostaglandins, which are known inflammatory mediators. However, after a soft tissue injury, prostaglandins may be produced rapidly, before NSAIDs are available to inhibit this pathway[16]. Also, many other mediators, such as kinins, histamine, and complements, may be present and allow an inflammatory response to progress even in the absence of prostaglandins. Analgesia has often been noted clinically with the use of NSAIDs. However, the analgesic effect of NSAIDs may be a central nervous system effect[13,14] and not necessarily related to their anti-inflammatory effects. Therefore, analgesics without anti-inflammatory effects may have similar effects as NSAIDs in these soft tissue injuries. The goal of this study was to compare the effects of NSAIDs and an analgesic without anti-inflammatory effects in an animal muscle contusion model. It was hypothesized that NSAIDs are no more effective in this injury than analgesics without anti-inflammatory effects unless the NSAIDs were given before the injury. If given before the injury, the COX inhibition is immediately available to affect the inflammatory response to the injury.

Materials and methods

Ninety-six adult male C57BL/6N mice (Jackson Animal Facility, Bar Harbor, Me) were used in this study. All animals were housed separately and had food and water ad libitum. All experimental protocols were approved by the Institutional Animal Care and Use Committee at our institution. In all animals, a unilateral muscle contusion injury was created in the tibialis anterior muscle. For this purpose, the animals were anesthetized by an intraperitoneal injection of Avertin (Sigma-Aldrich, St Louis, Mo) (0.017–0.05 mL/g body weight). Under general anesthesia, 1 leg was placed in a specially designed device, as described by Crisco and Jolk[7]. For our study, this device was slightly modified to accommodate the small size of the animals. The left limb was secured in a holding device to position the midportion of the tibialis anterior muscle exactly under the impactor tip. The ankle was placed in 90° of plantar flexion to create tension in the tibialis anterior muscle. A small impactor with a round 3 mm diameter tip was allowed to rest on the midportion of the muscle belly. A 50 g weight was dropped from a 10 cm height through a plastic guide tube. The weight dropped onto the impactor, driving it into the muscle belly without injuring the overlying skin. In our pilot studies, this action resulted in a contusion and damage to the muscle fibers with a subsequent inflammatory response but no macroscopic rupture (see Figure 1). After this injury protocol, the animals were allowed to wake up and were returned to their cages. After the injury, the mice were fed once daily with a pellet that was made from peanut butter mixed with their regular food. These pellets contained the drug, with the exception of the placebo group. The animals were observed until they had finished their pellets. They were provided with additional food ad libitum at that point. This protocol was repeated daily. The animals were divided into 4 treatment groups, each containing 24 mice. The animals in group 1 received a placebo dose once daily after the injury. In group 2, the animals received rofecoxib (Vioxx, Merck, Whitehouse Station, NJ) 5 mg/kg once daily after injury. The animals in group 3 received the same amount of rofecoxib as in group 2, but they received their first dose 24 hours before the injury. Group 4 received a dose of acetaminophen 200 mg/kg once daily after the injury. The drug dosages were based on the manufacturer's recommendations as well as reported dosages in the literature for therapeutic effects and avoidance of toxicity in mice[8,9]. Generally, rodents require higher per weight dosing compared to humans as a result of different metabolic rates. The animals were evaluated 2, 5, and 7 days after the injury. Before sacrifice, the animals were evaluated by a blinded observer for gait abnormalities as a result of the injury and treatment. Grade 0 was defined as no obvious gait disturbance, grade 1 was defined as an occasional lack of weight bearing by the animal, and grade 2 was defined as a constant unwillingness of the animal to bear weight on the injured extremity. The animals with gait disturbances would walk around their cages with their affected hind leg pulled up and would use only the remaining 3 extremities for weight bearing. If this was observed only intermittently, it was recorded as grade 1. The animals were subsequently sacrificed, and the tibialis anterior muscle was harvested by carefully opening the skin above the muscle on the lateral side. The muscle was carefully dissected in a standard fashion, removed, and immediately weighed. After weighing, the muscle was fixed in 10% formaldehyde for histologic evaluation. The muscle was sectioned longitudinally into 2 halves directly through the site of injury. Histologic slides of the cut edge were stained with hematoxylin and eosin. The histologic grading was done by a blinded observer by counting inflammatory cells and regenerating myotubes per high power field. First, the microscopic field was centered on the area of maximal injury under low power (see Figure 1). The magnification was then changed to × 400, and the cells were counted. The parametric data were analyzed with an analysis of variance, and the nonparametric data (gait data) were analyzed with a Wilcoxon rank sum test. Significance was set at $P < 0.05$.

Results

All animals completed the experimental protocol. Wet weight results showed that the placebo-treated group 1 had significantly increased muscle weights at day 2 compared to all other groups (see Figure 2). At days 5 and 7, no significant differences were found between groups. Scoring of the gait abnormality showed similar patterns, with significantly increased gait abnormality at postinjury day 2 in the placebo-treated group. Group 2 also showed a trend ($P = 0.14$ compared to group 4; $P = 0.18$ compared to group 3) toward increased gait abnormalities, but this failed to reach statistical significance (see Figure 3). Histology showed minor muscle cell disruption at day 2 in all groups. Increased numbers of inflammatory cells were seen particularly at day 5 compared to day 2 (see Figure 4). Myotube formation as a sign of muscle regeneration was present at days 5 and 7 (see Figure 5). No significant differences were appreciated between the groups.

Discussion

The results of this study indicate that an NSAID in this model is no more effective in treating a muscle contusion than an analgesic without anti-inflammatory effects, such as acetaminophen. All groups treated with acetaminophen and rofecoxib showed improvement in their gait at day 2, suggesting analgesic effects. The wet weights were also decreased in all treated groups at day 2 compared to the placebo-treated group. This may suggest an anti-inflammatory effect because the wet weight should be a reflection of edema within the muscle. However, acetaminophen-treated animals had similar wet weights, which suggests that the wet weights were decreased as a result of continued use of the muscle rather than anti-inflammatory action. Continued normal use of the extremity will promote circulation - in particular, venous drainage - which is likely to minimize any post injury swelling. The increased use may be related to the analgesia as a result of the acetaminophen treatment in that group. This is confirmed by the finding that the gait was improved in all rofecoxib-treated and acetaminophen-treated groups. Early administration of the NSAID, simulated in this study by giving the rofecoxib before the injury, did not appear to dramatically influence the results. Timing of the NSAID administration may still be of some importance. Even the "late" administration of the rofecoxib in group 2 was still relatively early, as the first dose was given as soon as the animals recovered from the injury protocol. In clinical practice, NSAIDs are often not prescribed for 24 to 48 hours after the injury. The cell and myotube counts did not show demonstrable differences between groups. This finding suggests that rofecoxib and acetaminophen do not have a dramatic effect on the cellular, inflammatory response and satellite proliferation. Myotube formation can be seen as an indirect measure of satellite cell proliferation. More advanced histologic techniques are required to directly study satellite cell responses. This experimental study has several drawbacks. First, limited aspects of the inflammatory response were measured; also, limited aspects of muscle function were measured. Contractile properties could still differ after acetaminophen versus NSAID treatment. Only one NSAID, with COX selectivity, was studied. It is possible that nonselective NSAIDs have different effects in this injury model. Finally, muscle healing in the animals used in this study differs from muscle healing in human muscle, in which muscle regeneration may be more limited. At this point, the results cannot be extrapolated to the human situation. However, without clear evidence of their effectiveness, the use of NSAIDs in muscle injury should be critically evaluated, and costs and side effects should be weighed against evidence of efficacy. Safer and less costly medication like acetaminophen may have equal effects.

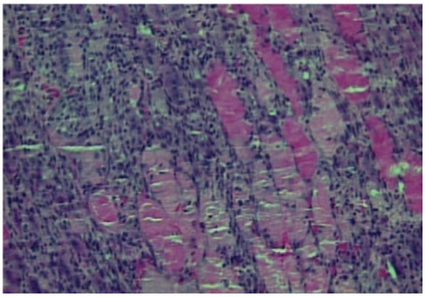

Figure 1

Histology slide of injured muscle tissue at 5 days after injury in group 1 (hematoxylin and eosin, × 160).

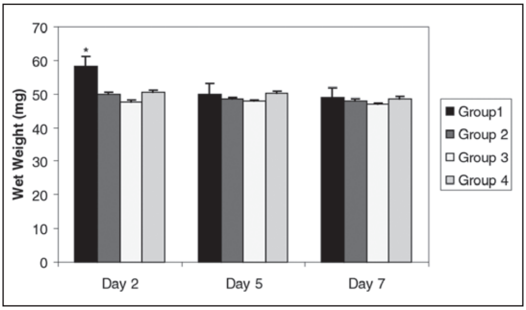

Figure 2

*Wet weight of the injured muscles at postinjury days 2, 5, and 7 in the 4 treatment groups. *, P < 0.01.*

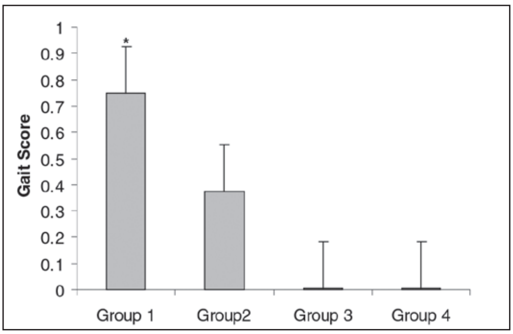

Figure 3

*Gait scores at postinjury day 2 in the 4 treatment groups. *, P < 0.01.*

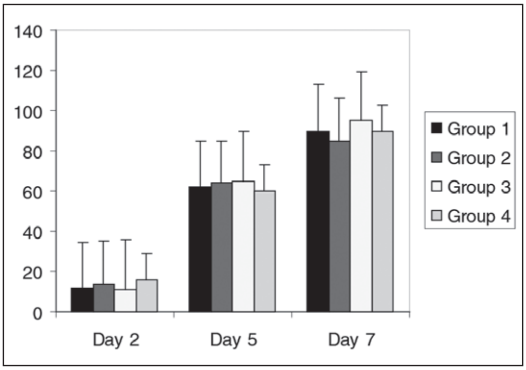

Figure 4

Nucleated cell counts at days 2, 5, and 7.

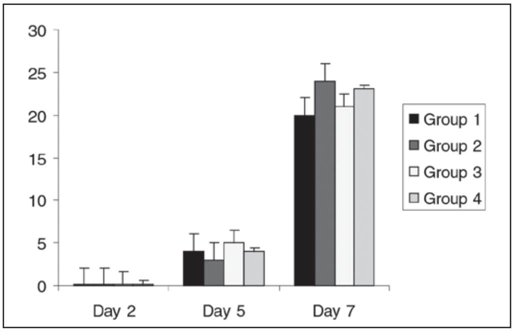

Figure 5

Myotube counts at days 2, 5, and 7.

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Chapter 4

The posterior transtriceps approach for intra-articular elbow diagnostics, definitely not forgotten.

van Wagenberg JM, Turkenburg JL, Rahusen FT, Eygendaal D.

Skeletal Radiol. 2012 May 11.

Abstract

Background and purpose: The elbow is among the most common joints that are aspirated and/or injected. An intra-articular approach should be a convenient and a safe procedure with minimal risk of complications. Several approaches to access the elbow joint have been outlined in literature, but a comparative study is lacking. This study evaluates the technical feasibility of the lesser performed posterior transtriceps approach with MR arthrography and compares it with the classic lateral radiocapitellar approach.

Patients and Methods: Using fluoroscopy guidance, MR arthrographies of the elbow were performed in 51 consecutive patients from 2006 to 2011. A classical lateral radiocapitellar approach was performed in 29 and a posterior transtriceps approach in 22 elbows. Studies were retrospectively reviewed with special attention to the extent of extra-articular contrast extravasation.

Results: Contrast leakage occurred in 12 radiocapitellar approaches, which caused a diagnostic dilemma in one subject. There was only minimal amount of contrast leakage in 5 subjects using the transtriceps approach and no diagnostic dilemmas occurred. Results show no significant differences between the approaches. No complications occurred in the posterior transtriceps group and all MR arthrographies were diagnostic.

Interpretation: The posterior transtriceps approach is a technical feasible procedure, is easy to perform and avoids a diagnostic dilemma in presumed injuries to the lateral collateral ligament complex. Our results show a tendency of even fewer amount of contrast leakage, further promoting a more widespread usage of the posterior transtriceps approach.

Level IV diagnostic study

Keywords: Elbow, Injections, Intra-articular, MR arthrography, Transtriceps, Radiocapitellar

Introduction

The elbow joint is among the most common joints that are aspirated and/or injected 5. Intra-articular access can play an important role in the evaluation and treatment of elbow pathology. In non-imaging related evaluation of pathology, aspiration of fluid permits laboratory studies like cultures for microorganism and histological analysis. Aspiration of fluid of the elbow joint has also shown to be highly contributory in decreasing pain in severe synovitis with extensive hydrops and fracture cases with intra-articular hematoma[2]. Injection of analgesics or cortisone is commonly used for elbow pathology such as synovitis, synovial folds and osteoarthritis.

Several approaches to the elbow joint have been outlined in literature. Most physicians access the elbow joint lateral over the radial head or posterolateral between the olecranon, humerus and radial head[1,4,5,14]. The lesser performed posterior transtriceps approach is located between the medial and lateral epicondyles and involves primarily the triceps muscle. The site of puncture is located at the fossa olecrani, an area without cartilage, whereas the lateral radiocapitellar approach might induce injury to the cartilage. The posterior transtriceps approach is presumed to be a technically easy and comfortable approach[7, 8, 9]. Surprisingly however, the transtriceps technique is not widely used and a study that compares the different approaches for technical feasibility and accuracy is lacking.

In this study we made an attempt to assess the technical feasibility of the posterior transtriceps (TT) approach and compare it to the lateral radiocapitellar (RC) approach with the use of MRI images. MRI has become a popular imaging technique to diagnose and evaluate articular surfaces, synovial lining, capsule size and integrity of the collateral ligaments with high accuracy[13]. It is generally accepted that MR arthrography increases sensitivity and specificity in diagnostic imaging. MR Arthrography has proved to enhance the sensitivity of standard MR and CT in the assessment of the collateral ligaments and in the evaluation of loose bodies and articular surface[3, 6,11,12].

We used this imaging technique to be able to observe the amount of contrast leakage which is an inconvenient occurrence that conflicts the evaluation of ligaments and supporting tissue[9,14].

Materials and methods

This is a retrospective study. All patients included in this study selected for MR arthrography were evaluated by an experienced upper limb surgeon and had clinical signs of collateral ligament injury, osteochondritis dissecans, or loose bodies. Patients who suffered from claustrophobia, had an allergy for contrast, had local skin defects or dermal infections around the elbow or who were younger than 12 years of age, were excluded for MR arthrography.

MR arthrographies of the elbow were performed in 51 consecutive patients from 2006 to 2011. General patient characteristics are summarized in table 1 and grouped in two different approaches; 29 patients were injected through a lateral RC approach from the year 2006 to 2008 and 22 patients through a posterior TT approach from 2008 to 2011. One patient in the RC group had to be excluded because of severe metal artifacts.

The area for either a RC or TT approach were first palpated and marked. The TT spot can be found in the middle between the medial and lateral epicondyl, proximal to the tip of the olecranon and just lateral to the central band of the triceps tendon (Figure 1). Following aseptic sterile preparations, the joint was injected with a 25-gauge needle under fluoroscopic guidance. The intra-articular needle position was verified by injecting 1 ml of iobitridol (Xenetix 300, Guerbet, Roissy, France). Subsequently, 8-10 ml of gadoteric acid/meglumine salt solution (0,0025 mmol gadoteric acid/ml Artirem, Guerbet, Villepinte, France) was injected. MR arthrography was performed within 30 minutes after the injection of the contrast medium.

Imaging Protocol

The MRI examinations were performed with a 1.5-T unit (Genesis Signa, General Electric Healthcare, Milwaukee, WI, USA). A GP Flex coil (General Electric Healthcare, Milwaukee, WI, USA) was used. Images were obtained with the elbow in full extension and the hand in supination. The following sequences were performed: coronal T1-weighted spin-echo (field of view, 12 cm; section thickness, 3 mm; section gap 0.3 mm; matrix 256x192 ; number of excitations [NEX], 2; TR/TE, 480/14); transverse pd-weighted fast spin-echo with fat saturation (echo-train length, 8; field of view, 12 cm; section thickness, 3 mm; section gap, 0.3 mm; matrix 256x192; NEX, 2; TR/TE, 3500/13.85); coronal short inversion time inversion recovery (STIR) (field of view, 12cm; section thickness, 3 mm; section gap, 0.3 mm; matrix 256x192 ; NEX, 2; echo-train length, 8;TR/TE, 3000/21; inversion time 160 milliseconds) and sagittal 3D spoiled gradient (SPGR) (field of view, 12cm; section thickness, 2 mm; no intersection gap; matrix, 256x256 ; NEX, 1; TR/TE, 27/9)

MRI Interpretation

The selected MRI studies were reviewed independently by two experienced musculoskeletal radiologists, with attention to the following criteria: extent of extra-articular contrast extravasation; pattern of signal and morphologic changes of the capitellum; abnormalities of the collateral ligaments of the elbow, including the medial collateral ligament (MCL), the lateral collateral ligament (LCL) complex; and the presence of other osseous and soft-tissue abnormalities such as tendon disorders. Contrast leakage was evaluated using a 3-grade scale; none, mild or moderate 9. The patients were all evaluated after a week at the outpatient clinic for possible discomfort, pain or other complications related to the procedure. Differences between types of approach in the amount of contrast leakage in each category were tested using the Fisher's exact test, as appropriate (PASW Statistics 18, Release 18.0.3 (Sep 9, 2010), SPSS Inc., Chicago, IL, USA).

Results

Using fluoroscopic guidance there were no difficulties in approaching the elbow in both groups. No modification to the injection route had to take place. The patients did not suffer from excessive pain related to the procedure, even in cases of lateral collateral ligament injury, and no later complications were observed.

There were no objective differences in quality of the MRI images between groups. Minor susceptibility artifacts due to air or microscopic metal after needle placement in a few subjects did not influence the diagnostic evaluation. A metal staple in the lateral epicondyl created local artifacts in one patient, but the images could still be evaluated for contrast leakage and was diagnosed with a lateral tendinopathy, without signs of ligament rupture. As mentioned in the materials and methods, there was one patient in the RC group with two screws through the lateral epicondyl that caused severe artifacts and was excluded from this study for comparison. MR-Arthrography findings are shown in table 2 (after exclusion of one patient because of metal artifacts). In 4 patients with a RC approach there was a moderate amount of leakage and the lateral LCL complex could be well interpreted for injury in three. Because of a diagnostic dilemma in one of these subjects (figure 2), an arthroscopy was performed, which showed an old avulsion fracture fixated to the synovium with signs of synovitis, but no collateral ligament rupture. This avulsion fracture was not visible on conventional X-rays.

Both groups show cases of mild contrast leakage that did not influence the interpretation. There were no diagnostic problems with the use of the posterior TT approach. Minor contrast extravasation jeopardized the quality of the images in one patient, following a lateral RC approach. A year later this same subject had a subsequent trauma. Another MR-Arthrography was performed using the TT approach showing no contrast leakage and confirming earlier findings with no signs of LCL complex injury (Figure 3).

The Fisher's Chi-square test was used in the analysis of contingency tables with nominal values, as appropriate. There were no significant differences between both techniques and the amount of contrast leakage ($p=0.161$).

Discussion

The intra-articular approach, of any joint, should be as easy and convenient as possible, but more importantly it should be a safe procedure with minimal risk of complications, such as hemorrhage, infection or chondral damage. The space of the fossa olecrani is larger than the area between radial head and capitellum, which theoretically should result in an easier access of the fossa.
Using the lateral approach, contrast leakage can lead to a diagnostic dilemma, especially in presumed injuries to the lateral collateral ligament complex[9]. The lateral aspect of the elbow is covered by a lesser amount of soft tissue, theoretically resulting in an increase of the risk of an infection or creating a fistula, as for example has been reported after arthroscopy[16]. The radiocapitellar joint is also prone to iatrogenic damage of the cartilage of the articular surface of the radial head or capitellum, which was observed in one of our patients on MRI.

The triceps muscle is rarely injured 15 making the posterior TT approach a logical and practical alternative, without a possible diagnostic dilemma in the evaluation of the lateral ligament complex. Also, the olecranon fossa has no cartilage that potentially can be injured and has more soft tissue coverage. The more extensive soft tissue coverage could even decrease the risk of an infection.
Some physicians in our clinic state that the posterior TT approach can be safely used without fluoroscopy. As stated by Lopes et al, an intra-articular injection in peripheral joints exhibit good accuracy if performed by a trained professional[10]. Fluoroscopy what we used in our population or ultrasound guidance can help the physician in further improving the accuracy[5].

Lohman et al also evaluated the posterior transtriceps approach for technical feasibility. They observed contrast leakage in a total of 13 out of 19 patients. In six patients a moderate amount of contrast leakage was displayed when more than 8 cc contrast agent was injected. Although we introduced an even or slightly higher amount of contrast (1 ml of iobitridol and 8-10 ml of gadoteric acid/meglumine salt solution) we did not observe a moderate amount of contrast leakage in the posterior transtriceps approach.

There were no significant differences between groups and all injections were diagnostic, indicating that the TT approach is evenly adequate. Our results are in favor of the posterior TT group in which contrast leakage was observed in 5 cases (23%) in comparison with the RC group that showed contrast leakage in 12 cases (43%). We find these results encouraging and promote a more widespread usage of the TT approach.

Conclusions

The posterior transtriceps approach is a safe and effective technique for arthrography of the elbow joint and should be considered instead of the classical RC approach.

Complications as infection, hemorrhage and chondral damage were not noticed in this study and the posterior transtriceps approach possibly reduce the amount of contrast leakage.

The problem of contrast leakage, as seen in the RC approach, which can lead to a diagnostic dilemma in presumed injuries to the lateral collateral ligament complex, is avoided.

Table 1

Patient characteristics

		Approach	
		Lateral Radio-capitellar (28)	Posterior Transtriceps (22)
Sex	Male/Female	14 / 14	11 / 11
Age	Mean (Standard Deviation)	31,9 (SD 16,1)	33,7 (SD 15,2)
	Median (Range)	23,2 (15-58)	33,9 (17-70)
Side	Left/ Right	12 / 16	14 / 8
Experiencing lateral complaints		12	9

Figure 1

Demonstrating the location of the posterior transtriceps approach

Table 2:
Findings MRA

		Approach	
		Lateral Radiocapitellar (28)	**Posterior Transtriceps (22)**
Contrast leakage	None	16	17
	Mild	8	5
	Moderate	4	0
Collateral ligament injury	LCL injury	2	3
	MCL injury	1	4
	LCL and MCL injury	1	0
Chondropathy		12	7
Loose bodies		8	7
Osteophytes		1	3
Bone marrow hyperintensity		1	3

Figure 2
MR arthrography images (coronal STIR sequence) demonstrating a moderate amount of contrast leakage (black arrow) and a susceptibility artefact (white arrow) after introduction of contrast using the radiocapitellar approach, causing a diagnostic dilemma

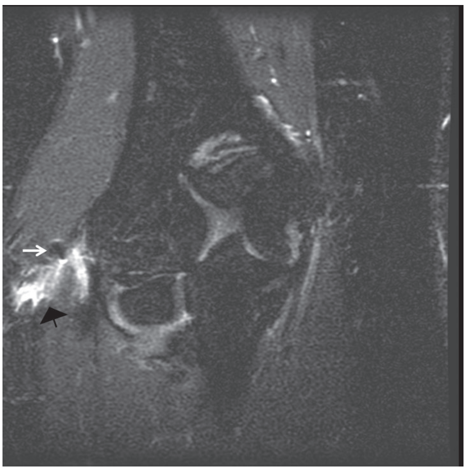

Figure 3

MR arthrography images using the radiocapitellar approach (a coronal T1WI and STIR sequences) showing a minimal amount of contrast leakage (white arrow) versus the transtriceps approach (b coronal T1WI and sagittal 3D spoiled gradient (SPGR) sequences) a year later in one subject with no contrast leakage and intact collateral ligament complex

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4

Chapter 5

Arthroscopic Surgery of the Elbow; Indications, Contra-Indications, Complications and Operative Technique.

Rahusen FT, Eygendaal D.

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Abstract

Arthroscopy of the elbow was first described by Burman in 1931. In this first article about arthroscopy of the elbow in the journal of bone and joint surgery, he concluded that the elbow joint was not suitable for arthroscopy; the joint was too small and the neurovascular structures in the anterior compartment of the elbow were close. In 1932 he revised his original article with some technical modifications and slowly arthroscopy of the elbow was performed more often. In the late 1980's arthroscopic surgery of the elbow became more and more popular. In this article an overview is given of the indications for elbow arthroscopy, the surgical technique is described in detail and the possible complications are highlighted.

Introduction

Since the eighties, arthroscopy of the elbow joint is performed more often as the understanding of the arthroscopic anatomy and its disorders have become more clear. Small performed an epidemiologic survey and in the late 1980's; only 0.77% of all arthroscopies in those days performed were arthroscopies of the elbow. Currently common indications for arthroscopy of the elbow are symptomatic loose bodies, posterior impingement, steochondritis dissecans (OCD), long standing lateral epicondylitis, persistent synovitis which require debridement or diagnostic biopsy, and stiff elbow due to arthritic changes or due to posttraumatic deformity. Peri-articular, endoscopic, techniques as a bursectomy, a tenoscopy of the biceps tendon or decompression of the ulnar nerve will not be discussed in this overview. Since the popularity of sports, especially the overhead throwing and racket sports, is growing, the incidence of elbow pathology is increasing. The technique of arthroscopic surgery has been improved dramatically last ten years; the incidence of complication as neurovascular damage is acceptable. In this overview the indications for elbow arthroscopy are listed, the surgical technique is described in detail and the possible complications are highlighted. The most common complication in elbow arthroscopy is neurologic deficit post-operatively. Also post-operative elbow stiffness, persistent portal drainage and infection have been mentioned. O'Driscoll and Morrey showed an overall 10% risk in their review of 70 patients. Other papers show complication rates between 0% and 15%. There are several techniques to perform an elbow arthroscopy. Mainly there are 3 different patient positions; supine, prone and lateral decubitus. All have their own benefits in different indications.

Indications for elbow arthroscopy

Diagnostic elbow arthroscopy

Diagnostic elbow arthroscopy is not advocated, but may be helpful when the clinical diagnosis is unclear. Also undetected elbow instability in overhead athletes can be seen during diagnostic elbow arthroscopy. Timmermans et al described an arthroscopic valgus instability test, in which a valgus load is applied to the elbow in 70 degrees of flexion during the arthroscopy. The medial compartment opens up and can be inspected. If the medial compartment open up for more than 2-3 mm, Field and Altchek* concluded that the ulnar collateral ligament can be torn.

Loose bodies

Symptomatic loose bodies are the most common indication for arthroscopy of the elbow. Loose bodies are often a symptom of an underlying disorder which has to be assessed and treated. Often, loose bodies are the result of a trauma, resulting in osteochondral fractures or fracture of (asymptomatic) osteofytes. Loose bodies are also formed in longstanding OCD or in synovial chondromatosis as described by Flury et al.; in both diseases additional arthroscopic treatment is indicated. Loose bodies may hide in any part of the elbow joint. Most commonly they are hided posteriorly in the olecranon fossa, at the posterior aspect of the radial capitellar articulation or anteriorly in the coronoid fossa. In case of loose bodies the surgeon therefore should assess all compartments of the elbow joint during the arthroscopic procedure. Preoperative radiographs and computer tomography is indicated and delineate in most cases the location of loose bodies.

Posterior impingement

Posterior impingement of the elbow is an uncommon disorder in the general young population; it is usually seen in patients that overuse their elbow during specific sporting activities as overhead throwing or tennis. During the throwing motion, in baseball, for example, the elbow moves during late cocking and acceleration phases from 110° to 20° of flexion with velocities up to 3000 deg/sec. This combination of valgus forces and rapid extension results in tensile forces along the medial side, compression on the lateral portion of the elbow, and shear forces in the posterior compartment. This combination is called valgus extension overload syndrome and forms the basic pathologic model behind posterior impingement of the elbow as formation of bony or soft tissue in the posterior compartment results in mechanical abutment leading to complaints of the posterior compartment during extension. The exact fit of the olecranon in the olecranon fossa of the humerus is critical for a maximal extension and, therefore, for the function of the elbow. In particular the maximal extension needed in most overhead sports is reduced, leading to complaints of the posterior compartment of the elbow. The athlete complains of pain posteriorly at the elbow, joint effusion, locking, crepitus, and a decrease in range of motion, most notably an extension deficit. X-rays, especially an axial view, may be helpful to detect osteophytes on the olecranon or on the borders of the posterior fossa. More sensitive is an MRI with intra-articular contrast; sensitivity for posterior soft tissue or loose bodies is nearly 90%. If conservative treatment of posterior impingement is not successful; arthroscopy of the elbow can be successfully used in these patients as described in an earlier review of Rahusen et al.

Osteochondritis dissecans

Osteochondritis dissecans is a localized condition involving the articular surface that results in the separation of a segment of articular cartilage and subchondral bone. The most common site of osteochondritis dissecans of the elbow is the capitellum although lesions have been reported in the trochlea, radial head, as well as the olecranon and olecranon fossa. Osteochondritis dissecans generally occurs in athlete's ages 11 to 21 years who report a history of overuse. The osteonecrotic lesion involves only a segment of capitellum, located primarily at a central or anterolateral position. Appropriate treatment of this disorder remains controversial. Often treated with benign neglect, this condition is a potentially sport-ending injury for an athlete, with long-term sequelae of degenerative arthritis. The surgical option is fragment excision with debridement of the necrotic lesion.

Longstanding lateral epicondylitis

Lateral epicondylitis or tennis elbow is a common disorder in primary care. It is rather related to manually intensive work, requiring forceful and repetitive rotation of the forearm, wrist extension or flexion (e.g. in mechanics, butchers, construction workers)The incidence of lateral humeral epicondylitis in general practice is estimated at 4-7 per 1000 patients per year, with a peak between 35 and 54 years of age. Lateral epicondylitis is generally a self-limiting condition. The average duration of a typical episode varies from six months to two years, but most patients (90%) respond to conservative treatments and recover within one year. Surgical treatment is recommended for those patients who are not responding to conservative treatment after at least six months to a year. Surgical techniques are various, including open, percutaneous and arthroscopic treatment. Research investigating which approach is superior, reveals that the less invasive approaches (percutaneous or arthroscopic) allow faster return to work, than the open procedure. Arthroscopic release is potential beneficiary because an arthroscopic evaluation of the whole joint can be done during the procedure. Also other intra-articular problems, which has been described in up to 50% of all cases, can be addressed simultaneously. Baker et al showed a return to work at an average of 2.2 weeks and a grip strength of 96% compared to the unaffected limb

Persistent synovitis

Persistent synovitis of the elbow, due to rheumatoid arthritis or other inflammatory pathology, which is not responding to conservative treatment, can be indication for debridement or diagnostic biopsy in cases the cause of the synovitis is unknown. De boer et al showed this in their studies. Septic arthritis of the elbow can be treated with arthroscopy as well.

Stiff elbow

Loss of motion is a common complication in degeneration or after elbow trauma. Restoration of joint motion especially in the posttraumatic stiff elbow can be a difficult, time-consuming, and a costly challenge (Lindenhovius et al. 2007). Elbow contractures can be the result of intrinsic (intra-articular) or extrinsic (extra-articular) causes[11,12,13]. In most posttraumatic contractures both intrinsic and extrinsic causes play a role. Established contractures should be treated initially with physical therapy and static-progressive splinting. Patients who have failed a minimum of 6 to 12 months of non-surgical management and who are motivated to comply with a strict postoperative rehabilitation program are candidates for surgical release[14]. Arthroscopic arthrolysis of stiff elbows has been introduced as a safe, but technical demanding technique (Sahajpal et al. 2009). The indications

for surgery depend on the patient's functional needs. Morrey et al. (1985) stated that an elbow needs a minimal range of motion (ROM) of 100 degrees flexion/ extension and 100 degrees of pronation/supination to function adequately in daily life. However in specific groups of patients, as professional athletes, even a slight extension deficit of 20 degrees can result in a dysfunction of the elbow.
Disadvantages of elbow arthroscopy include the inability to deal with ulnar nerve disease or heterotopic ossification and the length of the procedure.

Surgical technique
Arthroscopy of the elbow is routinely done under general anesthesia without additional regional anesthesia, to allow postoperative evaluation of the integrity of the nerves. With the patient still in supine position, the elbow is examined for range of motion and for instability. Then the patient is placed in supine or prone position. We generally perform the arthroscopy with the patient in a lateral decubitus position with the upper arm in a support with tourniquet. In this position all compartments are easily accessible. Alternatively the patient is positioned in prone, with the arm hanging down, or supine with the arm suspended and the elbow passively flexed in 90º. It is very important to identify and mark the bony landmarks and the ulnar nerve before insufflating the joint with saline. After this the joint is filled with 30 ml of saline, before making the first portal. Backflow of fluid verifies proper placement. Cadaveric studies have demonstrated that joint insufflation significantly increases the distance between the joint surfaces and neurovascular structures, thus helping to protect them from injury during joint entry and during the use of intraarticular instrumentation. When the arthroscopic sheath is inserted only blunt trocarts should be used. When creating portals, the surgeon should avoid penetrating the subcutaneous tissue, thereby helping to prevent injury to the superficial cutaneous nerves. A mosquito clamp can be used to spread tissues down to the capsule. A high pump pressure during the arthroscopy can result in loss of fluid in the soft tissues, resulting in compartment syndrome of the fore-arm. Insufflation of the joint above a pressure of more than 50 mmHg should be avoided. Portal placement is at the surgeon's distinction. Many portals have been described and specific portals have their own benefits.

Usually the direct-lateral, anteromedial, anterolateral and the proximal-medial portals are used for the anterior, lateral and medial compartment. The straight-posterior and posterolateral portals are used for the arthroscopy of the posterior compartment. The initial survey of the anterior aspect of the elbow is performed using the proximal medial portal: This allows localization of the loose fragments, their approximate position, and it allows the assessment of the medial and lateral gutters. The loose body is noted, and the proximal anterolateral portal is established by using the spinal needle to ensure adequate access with the pending entry. This portal is established, and the loose body is located, grasped, and removed. In many cases, it may be useful to "pin" the loose fragment with a spinal needle to provide resistance for grasping the loose piece of bone. Additionally, the portal may need to be enlarged to allow full excision of the fragment, or alternatively, it may be removed piece by piece. Using the antero-lateral portal the tip of the coronoid can be debrided, as well as the coronoid fossa. Most OCD are not visible from anterior. Lateral epicondylitis is debrided in the manner as well. With a standard arthroscopy of the posterior compartment of the elbow the olecranon fossa is cleared of soft tissue. Osteofytes at the posteromedial site of the proximal ulna or distal humerus can be debrided. Using a mid posterior portal and a postero-lateral portal the posterior compartment can be debrided using a 5.5 mm oscillating shaver and a 4 mm cylindric shaver burr. In case of arthrocopic artrholysis all osteofytes, loose bodies and fibrotic tissue are removed. The anterior compartment is examined using an antero-medial portal after a careful palpation of the ulnar nerve and intramuscular septum; a second portal antero lateral is created outside-in as described previously. With a 5.5 mm oscillating shaver a synovectomie is performed. With a 4 mm cylindric shaver burr, the coronoid process and the coronoid fossa are debrided. In the end the anterior capsule is released using a punch from medial to lateral. After treatment consists of Continuous Passive Motion device (CPM) for the first 24 hours, continuously, followed by a standardized program under supervision of a physiotherapist. The results of arthroscopic treatment compare favourably with those of open techniques with low rate of complications in both techniques. Elbow arthroscopy offers improved joint visualisation, reduced pain, smaller scars, accelerated rehabilitation and shorter hospital stay, potentially making arthroscopic release an outpatient procedure.

Complications in arthroscopy of the elbow

Most often complications of arthroscopy of the elbow are of neurologic origin. Usually the neurologic complications are transient but several authors describe total transection of the nerve, in particular the ulnar nerve. Transient radial nerve en median nerve problems have been reported, but the incidence is very low. Transient nerve deficiencies can be due to neuropraxia by compression of the nerve by instruments or by positioning of the patient on the table. Transection of the nerve mostly occurs by introduction of the scope or by capsulectomy anterolateral (radial nerve) or posteromedial (ulnar nerve)[17]. Excessive drainage from the portal sites has been described however the imported infection rate is low[8,18]. Temporary loss of motion is seen in most cases, but usually resolves within 6-8 weeks[8].

Conclusion

Indications for arthroscopy of the elbow are symptomatic loose bodies, posterior impingement, osteochondritis dissecans (OCD), long standing lateral epicondylitis, persistent synovitis which require debridement or diagnostic biopsy, and stiff elbow due to arthritic changes or due to posttraumatic deformity. The technique of arthroscopic surgery has been improved dramatically last ten years; the incidence of complication as neurovascular damage is acceptable.

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Chapter 6

Arthroscopic treatment of posterior impingement of the elbow in athletes.

Rahusen FT, Eygendaal D.

J Shoulder Elbow Surg.
2009 Mar-Apr;18(2):279-82.

Abstract
The purpose of this study was to evaluate the effectiveness of arthroscopic treatment of posterior impingement in the athletes elbow. 16 elbows were included. An arthroscopic debridement of the posterior fossa of the elbow was performed. All Patients were evaluated pre-operatively and after an average of 38 (30-53) months using range of motion, the Modified Andrews Elbow Scoring System (MAESS), VAS in rest and after provocation. The average flexion increased from 138º to 140º. The extension deficit of 8º pre-operatively increased to a deficit of average 2º ($P < 0.05$). The MAESS increased from average pre-operative to excellent post-operative ($P < 0.05$). The average VAS in rest decreased from 3 to 0 and during sporting activities the VAS decreased from 7 to 2 ($P < 0.05$).

In this series, arthroscopic debridement of the posterior fossa in athletes with posterior impingement is a procedure that showed excellent mid term results and can therefore be recommended.

Introduction

Posterior impingement of the elbow is an uncommon disorder in the general young population; it is usually seen in patients that overuse their elbow during specific sporting activities as overhead throwing or[3, 7, 11, 12, 16, 18]. During the throwing motion, in baseball, for example, the elbow moves during late cocking and acceleration phases from 110° to 20° of flexion with velocities up to 3000 deg/sec.[9] This combination of valgus forces and rapid extension results in tensile forces along the medial side, compression on the lateral portion of the elbow, and shear forces in the posterior compartment[1, 2, 4, 6]. This combination is called 'valgus extension overload' syndrome and forms the basic pathologic model behind posterior impingement of the elbow as formation of bony or soft tissue in the posterior compartment results in mechanical abutment leading to complaints of the posterior compartment during extension[1, 9]. The exact fit of the olecranon in the olecranon fossa of the humerus is critical for a maximal extension and, therefore, for the function of the elbow (Figure 1). In particular the maximal extension needed in most overhead sports is reduced, leading to complaints of the posterior compartment of the elbow[4, 13, 18, 19]. The athlete complains of pain posterior at the elbow, joint effusion, locking, crepitus, and a decrease in range of motion, most notably an extension deficit. X-rays, especially an axial view, may be helpful to detect osteophytes on the olecranon or on the borders of the posterior fossa (Figure 2). More sensitive is an MRI with intra-articular contrast; sensitivity for posterior soft tissue or loose bodies is nearly 90%.[5, 8, 17]. If conservative treatment of posterior impingement is not successful, arthroscopy of the elbow can be successfully used in these patients[14,15]. In this study the results of arthroscopic treatment of posterior impingement in 16 elbows is described.

Materials and Methods

Between 2000 and 2007, 16 elbows in 15 athletes (9 male, 7 female) average age 29 years, with posterior impingement unresponsive to conservative treatment (physiotherapy, rest, ice) for at least one year were treated by arthroscopic debridement of the posterior compartment of the elbow. All patients actively participated in sports that involved forceful, repetitive, flexion/extension of the elbow. All patients had complaints of pain, crepitus, locking and/or swelling. All were operated on the dominant side. Pre-operatively and at follow-up (average 38 months) elbow function was assessed using the Modified Andrews elbow scoring system (MAESS). In this scoring system 100 points reflects maximal function and 0 points reflects no function at all. Points are given for pain, swelling, locking, impairment of activities and for sports activities[10]. Pain was scored on a visual analoge scale (VAS) with 0 indicating no pain and 10, most severe pain. Pain was scored in rest and during sports activities. Radiographic assessment for degenerative changes was carried out using standard anteroposterior (AP), lateral and axial view plain radiographs. Only athletes with isolated posterior impingement were included in this study. Patients with underlying degenerative changes or valgus instability of the elbow were excluded. Stability of the medial collateral ligament was assessed, and if present, patients were excluded as they first underwent a stabilizing operation. All patients' details are summarised in Table 1. Students't-test was used to compare pre-operative and follow up values; $P < 0.05$ were considered significant. (Version 12, SPSS Inc, Chicago, Il, USA)

Surgical technique

All operations were carried out by the same orthopaedic surgeon (DE) in a standardized fashion. The patient was positioned in a lateral decubitus position under general anaesthesia. Prior to surgery, the elbow was tested for instability. A tourniquet was inflated around the upper arm; after distension of the joint, the surface anatomy was marked. An arthroscopy was performed through 4 or 5 portals; two placed anteriorly and 2 or 3 in the posterior compartment. After standard arthroscopy of the elbow, a debridement of the posterior fossa of the elbow was performed using a 3.5 mm shaver until there was no impingement of any soft tissue left and/or bony osteofytes visible. In some cases a high speed burr was used to remove large osteofytes. Loose bodies were removed using a grasper. Postoperative treatment consisted of 24 hours of immobilisation in a collar and cuff, followed by an active mobilisation programme under supervision of a physiotherapist.

Results

At follow up the flexion was 140° and the extension deficit was 2° (SD 2.6). The extension differed significantly from pre-operative value ($P < 0.05$). Pre-operatively the flexion was 138° (SD 9.5) and the extension was 8° (SD 8.9). Post-operatively, pronation and supination were 80° and 77° respectively and did not differ significantly from the pre-operative values. There were 11 elbows with an extension deficit of 5° or more (Table 1). 7 Patients complained about an extension deficit. This is reflected by a 10° or more extension deficit (Table 1). Not all patients with an extension deficit of 5° or more had osteofyts on the olecranon or in the posterior olecranon fossa. There were 7 patients with osteofyts and/or loose bodies. All but two patients resumed their sports activities at the pre-operative level, and all patients could resume their work within 3 months of surgery. Pre-operatively no patients had an excellent or good MAESS. 15 patients scored average and 1 scored poor. The MAESS increased from 69 (SD 9.9), reflecting an average score pre-operatively, to 93 (SD 5.7), reflecting an excellent score post-operatively ($p<0.05$). There were 4 patients with a good score and 12 patients scored excellent. The VAS in rest decreased from 3 (SD 2.2) to 0 (SD 0) ($P < 0.05$) and during sports activities the VAS decreased from 7 (SD 1.4) to 2 (SD 1.7) ($P < 0.05$) No complications such as dysfunction of the ulnar nerve or infection of the portal entries were seen. Further details are summarised in Table 1.

Discussion

In the largest available series documenting elbow arthroscopy, Reddy et al reported on 187 arthroscopies done in 172 patients. 15 That study was done in athletes in general; the most common diagnosis was posterior impingement (51%), followed by loose bodies (31%) and degenerative joint disease (22%). Although 68 patients were lost to follow-up, they reported 49% excellent, 36% good, 11% average and 4% poor results based on the modified Figgie score. In our study only patients with posterior impingement of the elbow were described and the average MAESS increased from 69 pre-operatively to 93 post-operatively ($P < 0.05$) which is better than in the study form Reddy. Preoperative degeneration or underlying valgus instability in the Reddy study, may be an explanation for the inferior results.

We specifically selected the patients to create a study population of patients that had posterior impingement without insufficiency of the MCL. In Reddy's study there were 3 transient complications, one of the ulnar nerve. We reported no complications.

In this study 16 athletes with posterior impingement of the elbow the MAESS, VAS and the extension deficit improved.

Short term results of this study show that arthroscopic debridement of the posterior fossa of the elbow in athletes is an effective and safe procedure. There were no complications and it therefore can be recommended as a safe treatment option for posterior impingement.

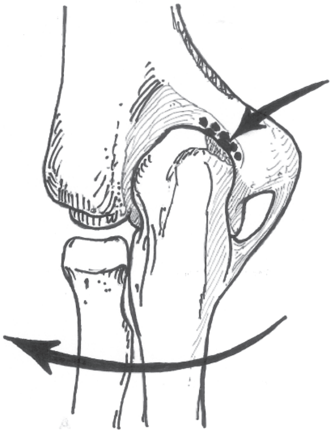

Figure 1

The exact fit of the olecranon in the fossa of the humerus is critical for maximal extension and, therefore, for the function of the elbow

Figure 2

Radiographs, especially an axial view, may be helpful in detecting osteophytes on the olecranon or on the borders of the fossa posterior

Case	Age Years	Gender	FU Months	sports	pain;rest pre/post-op VAS	pain;sports pre/post-op VAS	Flexion pre/ post-op	Extension pre/ post-op	MAESS pre-op	MAESS post-op
1	37	m	47	T	0/0	9/3	145/145	-5/-5	P	G
2	30	m	37	J	6/0	8/3	140/140	-10/-5	P	E
3	30	f	34	J	1/0	6/4	140/140	-5/-5	A	E
4	20	m	41	T	4/0	6/2	110/120	-5/-5	G	E
5	29	m	53	T	4/0	8/6	130/140	-10/0	P	E
6	23	f	34	O	1/0	9/4	150/150	-25/0	A	E
7	17	m	36	J	5/0	8/1	140/140	0/0	A	G
8	17	m	39	J	0/0	4/0	130/130	0/0	A	E
9	38	f	42	O	4/0	7/3	140/140	0/0	A	G
10	27	f	41	T	7/0	9/3	150/150	0/0	P	E
11	23	m	49	T	3/0	7/2	140/140	-30/-5	A	E
12	30	f	30	T	4/0	8/0	140/150	0/-5	P	E
13	26	f	32	T	2/0	6/0	140/140	-10/-5	A	E
14	29	m	32	O	0/0	5/1	140/140	-5/0	G	E
15	40	m	36	J	2/0	7/2	130/130	-15/-5	A	G
16	45	f	32	J	1/0	6/0	140/140	-10/0	A	E
	28,8		38,4		3/0	7/2	138/140	-8/-2	A	E

Table 1

Patient details

T = Tennis

J = Judo

O = Others as hockey and volleyball

MAESS

P = poor <60

A = average 60-79

G = good 80-89

E = excellent 90-100

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Chapter 7

Results after arthroscopic debridement for osteochondritis dissecans of the elbow.

Rahusen FT, Brinkman JM, Eygendaal D.

Br J Sports Med. 2006 Dec;40(12):966-9.

Abstract

Introduction: Osteochondritis dissecans (OD) usually occurs in the knee and the talus; only 6% of cases occur in the elbow. OD of the elbow usually affects the capitellum and is related to repetitive micro trauma to the elbow; complaints are frequently related to sportive activities. Ultimately it can result in loss of range of movement; sometimes in combination with locking. Treatment is dependent on the size and stadium of the lesion. Treatment options include debridement or an attempt at refixation of the lesion. The goal of this study was to determine the clinical outcome of arthroscopic debridement for OD of the elbow.

Methods: A prospective cohort study was started in 2000; between 2000 and 2004, 12 patients (3 male, 9 female, average age 32 years [range 15-52]) were treated for OD of the elbow by arthroscopic debridement. The dominant side was operated on in 5 of 12 patients and 6 of 12 patients were involved in a sport in which the elbow is used extensively. All operations were performed by one surgeon using standard arthroscopic technique. Elbow function was assessed pre- and postoperatively using the Modified Andrews Elbow Scoring System (MAESS); pain was scored on a visual analogue scale (VAS, 0 no pain, 10 severe pain). Evaluation was done at an average of 17 (4-34) months postoperatively. Statistical analysis was done using SPSS statistical software using the Student's T-test. $P < 0.05$ were considered significant.

Results: There were no complications. The range of motion did not improve significantly, the average MAESS improved from 66.3 (poor) preoperatively to 90.4 (Excellent) postoperatively ($P < 0.0001$). The average level of pain at rest decreased from 4 to 1 and the level of pain after provocation decreased from 7 to 2 ($P < 0.00001$). All patients were able to go back to work 3 months after surgery and 80% was able to resume their pre-injury level of sportive activities.

Conclusion: The clinical outcome in this series after Arthroscopic debridement for OD of the elbow shows that it provides excellent pain relief during ADL and sportive activities. The function of the elbow as reflected by the MAESS, improved from poor to excellent. All patients in this series will be reviewed after 2 years.

Introduction

Osteochondritis dissecans (OD) of the elbow is an uncommon disorder in the general population. It is usually seen in patients that overuse their elbow during specific sporting activities in which the elbow is extended forcefully or axially loaded[1,2,3,4]. In children OD has been described between the age of 10 and 17 years, mostly in patients who are engaged in sporting activities[3]. The aetiology of OD is unknown. There are several possible explanations for this disease as an ischemic event or repetitive micro trauma to the subchondral bone. In athletes the compressive load on the radio-humeral joint can become as high as 500N resulting in (osteo)chondral defects in the radiohumeral joint[5]. Symptoms of OD can be pain, effusion, crepitus, locking and clicking varying with the degree of loss of articular surface[6]. Athletes mostly complain of a dull and aching pain in and around the elbow shortly after sporting activities. Findings during physical examination can be swelling, tenderness over the radiohumeral joint and limitations in motion; especially loss of extension[7,8]. At standard radiography no changes are seen as the sensitivity of OD in early stages is low[9,10,26] In long standing OD, flattening of the capitellum and non-displaced fragmentation of the subchondral bone or even focal defects of the capitellum with loose bodies can be seen on an AP x-ray of the elbow (figure 1). Magnetic resonance imaging, preferably with arthrography, is the first choice to evaluate OD. Sensitivities up to 95% have been reported[9]. Treatment is dependent of the severity, size and location of the lesion. Also age of onset plays a significant role[11]. Baumgarten has developed an arthroscopic classification to determine what treatment should be used for which severity of OD of the elbow[27]. He described 5 gradations of the lesion. A grade 1 lesion is a lesion which shows smooth but soft, ballotable articular cartilage. A grade 2 lesion shows fibrillations or fissuring of the cartilage. A grade 3 lesion showed exposed bone with a fixed osteochondral fragment. A grade 4 lesion showed a loose but undisplaced fragment. Finally a grade 5 lesion showed a displaced fragment with resultant loose body. Recent studies have shown that early capitellar lesions can resolve with activity modification and rest if the defect is diagnosed early on in the development[4]. On the other hand, Takahara et al. showed fair to poor results in conservatively treated OD of the elbow[21,22] 24 patients, aged 11-16 years were treated by activity modification for a period of 6 months. After 5 years 83% had fair to poor results and the authors concluded that the capitellum has poor healing potential with conservative management. The role of physiotherapy and NSAID's remains unclear. No randomized trials are available on this subject. If conservative treatment of OD is not successful, surgical treatment can be an option. Surgical procedures can be open debridement, subchondral drilling, bone grafting, refixation, chondral transplantation or osteotomy[10,12,13] Refixation is recommended in case of large fragments. If refixation is not possible as in smaller fragments, debridement of OD is an option[15]. The goal of this study was to examine the results of arthroscopic treatment of OD in 15 elbows.

Patients and Methods

Between 2000 and 2005, 15 patients (6 male, 9 female, average age 28 years [range 18-49]) were treated for OD of the elbow by arthroscopic debridement. The dominant side was operated on in 7 of 15 patients and 14 of 15 patients were involved in a sport in which the elbow is used extensively. All operations were performed by one surgeon using standard arthroscopic technique. The lesion was graded according to a classification described by Baumgarten. Elbow function was assessed pre- and postoperatively using the Modified Andrews Elbow Scoring System (MAESS); pain was scored on a visual analogue scale (VAS, 0 no pain, 10 severe pain). Evaluation was done at an average of 45 (18-59) months postoperatively. Statistical analysis was done using SPSS statistical software using the Student T-test. $P < 0.05$ were considered significant.

Surgical technique

Prior to surgery the elbow was tested for stability under general or regional anaesthesia. With the patient in lateral decubitus position and with a tourniquet inflated around the upper arm, an arthroscopy was done through 4 standard portals; two placed anteriorly and 2 posteriorly. Before placement of the portals, the ulnar nerve was marked and the joint distended with 10-20 cc saline by a posterior injection into the fossa olecrani. The radiohumeral compartment of the elbow was visualised through standard portals and osteochondral lesions of the capitellum and the radial head could be assessed. Figures 2 and 3 show a grade 4 and 5 lesion according to Baumgarten[27]. Loose bodies were removed, using a grasper. Debridement was performed using a 3.5 mm shaver; all loose fragments and loose cartilage was removed until subchondral bone was seen. Postoperative treatment consisted of 24 hours of immobilisation in a collar and cuff, followed by an active mobilisation programme under supervision of a physiotherapist.

Results

In these series there were no grade 1 or 2 lesions. There were six grade 3 lesions, five grade 4 lesions and four grade 5 lesions with subsequent loose bodies. All grade 3 lesions were probed and the soft osteochondral lesions were debrided with a high speed borr. Grade 4 and 5 lesions also were debrided until subchondrale bone was seen. There were no complications. The range of motion did not improve significantly, the average MAESS improved from 65.5 (poor) preoperatively to 90.8 (Excellent) postoperatively ($P < 0.0001$). The average level of pain at rest decreased from 3 to 1 and the level of pain after provocation decreased from 7 to 2 ($P < 0.00001$). All patients resumed work within 3 months after surgery and 80% of the patients were able to resume their pre-injury level of sportive activities (Table 1).

Discussion

After tendinopathies and posterior impingement, osteochondritis dissecans, is the most common injury of the elbow in athletes[16]. Accurate diagnosis depends on understanding anatomy and sports biomechanics of the athletes elbow as the athlete often complaints of pain during sporting activities and is asymptomatic during daily life[17,18,19] As OD can also be associated with ligamentous instability of the elbow, the elbow always has to be evaluated for valgus instability preferably under general anaesthesia[2,1,17,18,19] X-rays, may be helpful to rule out other causes of elbow pain such as osteofyts on the olecranon or on the borders of the posterior fossa.

Gender	Age years	FU months	Side	sports activities	pain pre-op rest/act (VAS) pre-op	pain post-op rest/act (VAS) post-op	flex pre/ post-op	ext pre/ post-op	pro pre/ post-op	supi pre/ post-op	MAESS pre-op	MAESS post-op	Grade
F	49	55	L/-	tennis	3/7	1/3	150/140	-5/0	80/80	80/70	A	E	3
F	24	47	L/+	Judo	2/7	1/2	140/140	0/0	80/80	70/70	P	E	4
M	16	49	R/+	fitness	3/6	0/3	140/140	-5/-5	80/80	70/70	A	E	4
M	24	31	R/+	tennis	6/7	0/2	140/140	0/0	80/80	80/80	A	E	5
F	27	50	R/-	gymnastics	4/7	0/3	150/140	-5/-5	90/80	90/70	G	G	5
F	25	55	L/-	volleybal	2/2	7/7	150/140	0/-5	80/80	80/70	A	G	5
F	29	59	L/-	judo	3/7	0/0	150/140	0/0	80/80	80/80	A	E	5
M	44	59	R/+	judo	1/6	0/2	160/160	0/0	80/80	90/70	A	E	4
F	40	52	R/+	Athletics oid	4/7	2/0	160/140	-30/-20	80/80	80/80	G	E	3
F	16	41	R/+	gymnastics	5/7	0/2	150/150	0/0	80/80	70/70	A	E	3
M	22	42	L/-	tennis	0/10	0/1	130/140	0/0	90/80	80/80	G	E	4
F	24	42	L/-	gymnastics	7/9	0/1	140/130	-5/0	90/80	70/70	P	G	3
F	29	44	L/-	horseriding	3/7	2/4	140/140	0/-20	80/80	80/80	P	A	4
M	20	18	L/-	Tennis	3/7	0/1	140/140	0/0	80/80	80/80	P	E	3
M	24	30	R/+	Tennis	7/9	0/2	140/140	0/0	80/80	80/80	P	G	5

Table 1 legends

FU=follow-up R=right; L=left

+ =operation on dominant arm

Extension pre-op/post-op: negative value indicates an extension deficit

MAESS=modified Andrews scoring system

P=poor (<60); A=average (60-79); G=good (80-89); E=excellent (90-100)

Flex and ext = flexion and extension of elbow

Pro and sup = pronation and supination of elbow

In grade 1-4 lesions X-rays will not show pathology. Only the grade 5 lesions will show flattening of the capitellum. If conservative treatment fails, arthroscopic or open debridement is the primary treatment option for OD of the elbow[20]. Controversy exists about when to treat and what treatment is the best option[21,22] Ruch et al. treated 12 elbows with arthroscopic debridement after failure of conservative management[23]. He had good short-term results after 2-5 years. Byrd treated 10 elbows[7]. All patients had good outcome on a 200-point objective and subjective rating scale, but only 4 of 10 patients returned tot their pre-operative level of sports. Shimada et al reviewed the literature in 2003. Using an autograft for advanced OD of the elbow he concluded that there was a favourable outcome[13].He also concluded that there are several options in the operative treatment of different severities of OD. Simple abrasion of advanced lesion is popular but not indicated if there is a large lesion. Refixation of the lesion is a reasonable treatment option but only when a bony union can be expected. Some authors have reported good outcome[24,8]. Shimada reported that recurrence of loose bodies and advancement of osteoarthritis will occur in patients with advanced OD[13]. These unfavourable results were seen in OD lesions greater than 10 mm in diameter. There are few publications on pure arthroscopic treatment of OD in the elbow. Several series about OD treatment with an open surgical approach of the elbow are available, all with variable outcome and all with short-term results. Previous studies of different techniques have shown varying results[13]. Yadao and Cain, however, described a relation between OD and osteoarthritis on the long term disregarding the technique use[4,25]. They both concluded that an untreated OD lesion will eventually lead to loose bodies and subsequently osteoarthritis and thus early treatment, whether conservative or operative is imperative.

The short term results of this study show that arthroscopic debridement of the chondral defect of the elbow in athletes is an effective procedure, as reflected by the improvement of their MAESS and VAS score. However improvement of MAESS and VAS did not result in return to previous level of sports in all patients (80%). There were no complications and it therefore can be recommended as a safe treatment option for OD. Evaluation of these patients after 5 years will be done to assess if the long term results of debridement of the OD results in persistent good outcome in the future. In conclusion arthroscopic debridement of OD in the elbow in athletes results in satisfactory short-term outcome, however not all athletes were able to return to their previous level of sports activities.

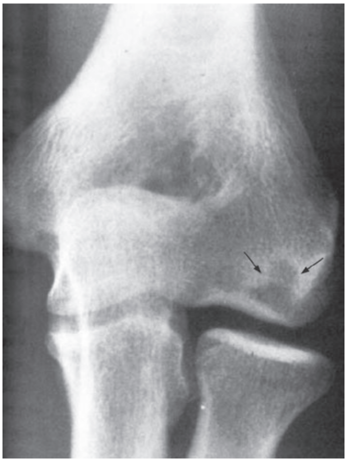

Figure 1

AP Radiograph with Osteochondral lesion

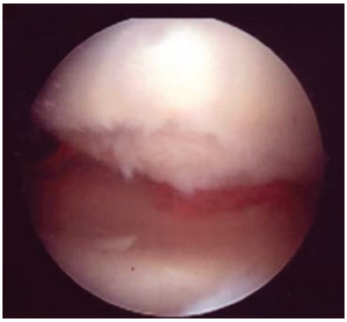

Figure 2

Osteochondral lesion of the capitellum (Grade 4 lesion)

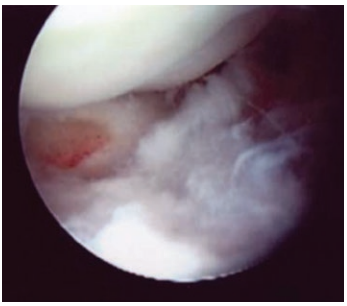

Figure 3

Osteochondral lesion of the Radial head (grade 5 lesion)

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Chapter 8

Long term results after Ulnar Collateral Ligament reconstruction of the elbow in European athletes with interference screw technique and triceps fascia autograft.

Kodde IF, Rahusen FT, Eygendaal D.

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Abstract

Background: Last decades there is an increasing interest in Medial Ulnar Collateral Ligament (MUCL) reconstruction techniques for MUCL insufficiency of the elbow. All case series are based on American and Asian Athletes and use primarily a palmaris longus tendon or gracilis tendon as an autograft in reconstructions. A new technique is the interference screw fixation. Evidence that supports the use of this technique are mainly from controlled laboratory studies. The purpose was to evaluate the interference screw technique for MUCL reconstructions in a European, clinical setting, with a triceps tendon fascia autograft.

Methods: 20 consecutive athletes with diagnosed MUCL insufficiency that underwent a MUCL reconstruction using the interference screw technique were retrospectively reviewed. Indications for reconstruction were medial elbow pain and/or instability caused by insufficiency of the MUCL that prevented the athlete from sport activity after a minimum of 3 months of conservative treatment.

Results: At a mean follow up of 55 months (range 36 – 94) the mean MEPI score improved from 82 to 91 points (range 80 – 100); $P < 0.001$. In the end, six patients (30%) quitted the sport activities they were preoperatively participating in, all because of reasons unrelated to the MUCL reconstruction. There was an excellent result on the Conway scale in 18 patients.

Conclusion: Good results are reported based on the postoperative MEPI and Conway score with clinically stable MUCL reconstructions without signs of break out or fractures on radiographic follow-up. However, the dropout, even after successful reconstruction in European athletes is high.

Introduction

The anterior bundle of the Medial Ulnar Collateral Ligament (MUCL) is the primary constraint to valgus stress between 25º and 125º of flexion[14, 24, 36]. Injury to the MUCL can be the result of an acute traumatic moment or is the result of repetitive microtraumata to the MUCL caused by overhead athletic activities. During the late cocking phase of throwing there is a valgus load of up to 64 N.m., resulting in tensile forces medially, which exceed the native strength of the MUCL.14 Thus, injury of the MUCL of the elbow occurs most frequently in overhead athletes. Before Jobe et al described a reconstruction technique for the MUCL in 1986, this injury was often career ending[19]. Conservative treatment of MUCL injuries in baseball players was indeed successful in only 42%[28]. Since Jobe's original article, the interest in MUCL injuries has substantially increased and involved different kinds of sports activities such as baseball, football, soccer, tennis, javelin throwing and gymnastics[6, 9, 10, 16]. According to a recent systematic review by Vitale et al35 the results of MUCL reconstruction evolved from 68% good results in the earliest study[7] to 95% in the most recent study[20]. During this period there was an evolution of reconstruction techniques from Jobe's figure-of-8 technique[19] to the docking technique[29] and subsequent modifications[20, 26] to the docking technique. Most reports are based on American, Australian or Asian athletes; reports on MUCL reconstruction in European athletes are rare. More recently new fixation techniques were introduced such as the bioabsorbable interference screw fixation and interference knot fixation[1, 8, 30]. For reconstruction of the MUCL palmaris longus tendon or gracilis tendon in absence of the palmaris longus, is most often used[5, 6, 8, 11, 19, 20, 26, 29]. Based on worldwide population studies, the prevalence of absence of the palmaris longus tendon varies from 4.6% in Chinese[32] to 37.5% in Serbian[12] people. Using the gracilis as graft is less attractive as an uninjured knee is harmed by means of a technically demanding operation only to harvest a graft, with the risk of inadequate graft length[2]. Moreover the gracilis cannot be used anymore in future anterior cruciate ligament surgery. As an alternative, the fascia overlying the triceps muscles can be used as an autograft. Biomechanical studies by Baumfeld and co-workers showed that the fascia overlying the triceps is strong enough to serve as a graft for MUCL reconstruction[4]. Previous reports, using triceps tendon fascia graft have shown promising results[13, 22, 31]. The postoperative triceps strength was not significantly diminished according to Olsen and Martin[22, 25]. However, these conclusions are based on retrospective studies with small sample sizes of patients not performing overhead sport activities. Eygendaal et al used triceps fascia grafts in athletes with good results by means of return to previous levels of sports, but did not specifically report on postoperative triceps strength[13]. The purpose of this study was to evaluate the long term results of MUCL reconstructions in a cohort of European athletes using the interference screw technique and triceps fascia as an autograft. The interference screw technique was used because of the easy and safe approach with minimal muscle dissection and risk to the ulnar nerve. The graft is fixated in more reliable anatomic bone tunnels according to the anterior bundle of the MUCL, with easy tensioning and without the risk of any bone bridge fractures. We hypothesized that there would be good results after this more easy and safe MUCL reconstruction with triceps fascia autograft and bioabsorbable interference screw fixation.

Material and Methods

From 2001 through 2007, 20 consecutive athletes with MUCL insufficiency were treated with a surgical reconstruction by the senior author. Indications for reconstruction were medial sided elbow pain and/or symptomatic valgus instability caused by insufficiency of the MUCL. In all athletes a conservative treatment was attempted for at least 3 months under supervision of a physical therapist. The interference screw technique, with bioabsorbable screws (Arthrex Inc., Naples, FL) was performed in all patients. The diagnosis was based on the history, physical examination, standard radiographs and Magnetic Resonance Imaging (MRI). All patients underwent a pre-operative clinical assessment consisting of Range Of Motion (ROM), assessment of (valgus) stability and calculation of Mayo Elbow Performance Index (MEPI). Radiographs in Anterior-Posterior (AP) and lateral direction of the effected elbow were obtained before surgery. Postoperative clinical evaluation took place at 8 weeks, 6 months, 1, 3, and 5 years, and consisted of ROM, strength, stability, neurological status and standard radiographs in AP view and lateral direction. MRI arthrography was not routinely performed during postoperative evaluation. The MEPI questionnaires were completed. AP and lateral x-rays were assessed for fractures around the drill holes, Heterotopic Ossifications (HO) and position and absorption of the bioabsorbable interference screw. HO were classified according to Hastings and Graham[17]. Final results were graded on the Conway scale[7]:

- Excellent: return to pre-injury level of competition for more than one season.
- Good: return to play at a lower level of competition for more than one season.
- Fair: able to play regularly at a recreational level.
- Poor: unable to play at any level.

Statistical analysis was performed using SPSS 16.0 for windows (SPSS inc, Chicago, IL) software. Statistical analysis was done using the paired T-test, sign test and Wilcoxon signed ranks test to compare preoperative and postoperative changes in numerical data between groups. The results were considered statistically significant at $P < 0.050$.

Surgical technique

The patient is placed in supine position with the arm on a surgical hand table. The arm is routinely prepared and draped up to the shoulder and a sterile tourniquet is applied. An incision over the medial epicondyle is made, carried down through subcutaneous tissues while the ulnar nerve is protected. For harvesting of the graft the incision is 3-4 cm longer in comparison to traditional techniques. A release of the ulnar nerve was not routinely performed, unless there was a preoperative ulnar nerve dysfunction. A longitudinal split is made in the common flexor bundle[34]. The anatomic origin and insertion of the MUCL are exposed. The triceps graft is collected through the same incision and measures about 8-10 cm in length and 1.5 cm in width. It is harvested from the middle third part of the triceps fascia overlying the muscle bellies of the triceps tendon without damaging the lamina splendens (the muscular septum between the lateral head and the medial/long head of the triceps). The defect of the triceps fascia is not closed. The thickness of the graft averages 2 mm. The graft is folded along its long axis and both ends of the graft are braided with Mersilene 000 Krackow stitches. (See figure 1) A 5 mm ulna drill hole is made just at the tubercle of the supinator crest with optimally a 2 or 3 mm distance between the articular surface and the ulna tunnel. The drill hole should be directed towards a point distal of the supinator crest on the lateral ulna. The drill hole is debrided with a curette to remove sharp bony edges to prevent trauma to the graft by the screw. The graft is fixed in the ulna with a 5.5 mm bioabsorbable interference screw using the Bio-Tenodesis cannulated screw Driver (Arthrex Inc., Naples, FL). See figures 2 and 3. Isometry is determined by holding the graft at the origin of the MUCL on the humerus during flexion and extension. At that point on the medial epicondyle a 5-mm tunnel is created and debrided with a curette to prevent blow out of the medial epicondyle. Two 1.5 mm exit holes are drilled from proximal to distal in the medial epicondyle, connecting to the larger tunnel and preserving a 5 to 8 mm bone bridge between the two smaller tunnels. In maximal supination with varus stress and 60-70 degrees of flexion, the graft is fixed with a second bioabsorbable 5.5 mm interference screw and the two suture ends are fixed to each other over the bone bridge. Any remnants of the original ligament are sutured over the graft for additional protection. The flexor muscle fascia is closed, the tourniquet is released, haemostasis is performed as necessary and the skin is closed. See figure four for the final result.

Rehabilitation

The arm is placed in 90º of flexion with neural rotation in a plaster splint for one week. After one week the range of motion is steadily increased without restriction until full under strict guidance of a physical therapist. Muscle-building exercises were started while care was taken not to apply a valgus stress at the elbow during this phase of rehabilitation. After 4 months patients could gradually start with sporting activities according to sport specific protocols.

Results

Of the 20 patients included in this study, the mean age at time of reconstruction was 22 years (range 18 - 35). Seven patients (35%) were men and 65% were female. The study group included 6 javelin throwers, 4 gymnasts, 3 judo players, 3 handball players, 2 baseball players, 1 swimmer and 1 horseman. All had medial sided elbow pain and all had a grade 3 valgus instability, consistent with MUCL insufficiency. Ulnar nerve symptoms were present in 4 patients (20%), but there were no nerve conduction studies performed as the symptoms in all cases decreased spontaneously. An acute trauma was the cause of MUCL rupture in twelve patients (60%). The mean preoperative MEPI score was 82 points (range 70 - 90). There were no significant differences in gender distribution, age and Conway scale between patients with or without an acute trauma of the MUCL. Demographic data is presented in table one. The mean time between onset of symptoms and MUCL reconstruction was 19 months (range 3 - 40). During this period most patients participated in a rehabilitation course consisting of rest, physical therapy and a structured attempt to return in sporting activities. No patients were lost to follow up and at a mean follow up of 55 months (range 36 - 94) the mean MEPI score improved to 91 points (range 80 - 100); $P < 0.001$ (95%CI of the difference 3.96 - 13.54). The mean MEPI score improved significantly more in patients who had an acute MUCL trauma compared to the patients that had attritional tears; $P < 0.022$. Six patients (30%), of which three were female, quitted the sport activities they were preoperatively participating in, all because of reasons unrelated to the MUCL reconstruction. Two patients left sports within one year after reconstruction (one because of persistent posterior impingement and one because of financial reasons), four patients stopped after they returned at their pre-injury level for two or more years following surgery. This group consisted of two javelin throwers, one baseball player, one gymnasts, one swimmer and one horseman. The other 14 patients returned and continued to play at their pre-injury sports level. Of the 20 patients, 18 (90%) had an excellent result on the Conway scale and two had a poor result. All patients had a clinically stable MUCL. There were no postoperative infectious complications. One patient had a persistent ulnar nerve dysfunction.

At radiological follow-up there were two patients (10%) with signs of HO classified as Hastings and Graham class 1.

The latter two patients had an arc of ulnohumeral motion of 100º (turner, continued playing) and 120º (horseman, quitted within one year). There were no signs of malposition of the bioabsorbable interference screws or fractures around the bone tunnels. None of the patients required additional surgeries later on their elbows.

Discussion

The interference screw technique was first described by Ahmad and co-workers in a controlled laboratory study in 2003[1]. They tested 10 matched pairs of elbows divided in a control group and reconstruction group with a metal screw in the ulna and humerus. The elbows were tested for a maximum load at 70º flexion. Pair wise comparison of the control and reconstructed elbow showed that the ultimate moment of the constructed elbow was 95% of the intact elbow.

In 60% was the mode of failure graft rupture. Furthermore they suggested that this technique is technically less demanding with one ulna tunnel, and the risk to damage the ulnar nerve is lowered. Two years later Armstrong et al[3] reported about a biomechanical comparison of four MUCL reconstruction techniques. The four reconstruction techniques included figure-eight reconstruction, docking technique, endobutton fixation and the interference metal screw technique. The interference screw technique was inferior to the docking technique and the endobutton in means of peak load. They found it difficult to introduce the interference screw in the ulna without damaging the graft, because the graft was cut by the screw threads. A possible explanation for this is the use of metal screws that are too hard and sharp. Also, they used a single-strand graft. Subsequently there were three laboratory studies published in 2007 that evaluated the interference screw technique[15, 21, 23]. Furukawa et al[15] compared the docking technique with the interference metal screw technique with the use of a palmaris longus graft versus a Graftjacket (modified dermal allograft tissue) graft. With the use of a

Table 1: demographic data

case	gender	age	acute trauma	sport	follow up (months)	MEPI Pre-op	MEPI Post-op	Quitted (after ... months)	Conway scale
1	F	18	1	Judo	49	90	100	N	E
2	M	24	1	baseball	50	80	100	Y (>30)	E
3	M	19	1	Javelin	66	80	90	N	E
4	F	18	0	Gymnast	58	90	90	N	E
5	F	19	1	Handball	36	70	90	N	E
6	F	18	0	Gymnast	60	90	100	N	E
7	F	25	0	Javelin	94	80	90	Y (>24)	E
8	M	18	0	Javelin	64	80	70	N	E
9	M	31	0	Handball	46	80	90	N	E
10	F	18	0	Baseball	60	90	80	N	E
11	F	35	0	Judo	60	90	90	N	E
12	F	20	1	Gymnast	64	80	85	N	E
13	F	18	1	Javelin	42	80	90	N	E
14	M	18	1	Gymnast	47	90	80	Y (<12)	E
15	F	20	1	Swimmer	54	90	100	Y (>36)	E
16	M	29	0	Javelin	46	80	90	Y (>36)	P
17	F	28	1	Handball	48	80	100	N	E
18	F	26	1	Horseman	47	60	80	Y (<12)	P
19	M	20	1	Javelin	49	80	100	N	E
20	F	26	1	Judo	59	80	100	N	E

E = excellent, F = female, M = male, N = no, P = poor, Y = yes.

palmaris longus graft the results for the docking technique and interference screw technique were comparable. Modes of failure were graft slippage (46%) and graft rupture in 15%. Large et al[21] compared the interference metal screw technique with Jobe's figure-eight technique and found the latter to be superior for reconstruction stiffness and work required to produce 10º of angular displacement. The last group that biomechanically evaluated the interference screw technique was McAdams et al[23]. They compared the interference bioabsorbable screw technique with the docking technique after cyclic loading. The interference screw reconstruction was significantly more stiffer than the docking technique with regard to resistance to valgus torque. Based on the previous five mentioned biomechanical studies it is unclear which MUCL reconstruction technique is the best. (See table 2) Only McAdams et al used bioabsorbable screws and they found no failures at the interference screw site. In contrast Armstrong, Furukawa and Large used metal screws to prevent graft slippage and noticed graft slippage in 70% and 100% of cases, respectively. A biomechanical study by Hurbanek evaluating the addition of a bioabsorbable interference screw at the humeral side of the docking technique resulted in a laxity no different than the intact native MUCL. Among the failures the graft slipped past the undersized screw four times[18]. Interestingly Ahmad and Armstrong used 5.0 mm screws for 5.0 mm tunnels, Large used 5.0 mm screws for tunnels with a diameter of 5.5 mm and Hurbanek used a 4.75 mm screw for a 5.0 mm tunnel, whereas McAdams used an oversized screw of 4.75 mm for a tunnel of 4.5 mm. This is to our knowledge the first clinical outcome study evaluating the interference screw technique to reconstruct the MUCL at the elbow. At a mean follow-up of 55 months there were no clinical signs of graft failure. Radiological evaluation showed no complications at the interference screw site. In this study we have used 5.5 mm bioabsorbable screws for 5.0 mm tunnels. This might create a better graft fixation in the tunnel to prevent slippage, while the stress in the tunnel is within limits in relation to fractures around the tunnel.

We believe that oversized screws are safe as long as they are bioabsorbable, since there were no fractures associated with screw insertion both in this study as well as McAdams'[23]. Based on the previous mentioned biomechanical studies and this study is graft fixation with oversized bioabsorbable screws superior, since the combination of oversizing and bioabsorbable screws was the only one that resulted in no complications. Furthermore we prefer bioabsorbable interference screws as these screws can be replaced by normal bone. However, in all patients, the drill holes are still visible on radiographs at latest follow-up and

Table 2: comparison of the interference screw technique in the literature.

Author	Year	Test	Graft	Screw	Comparison	Results
Ahmad et al[1]	2003	1. failure load 2. stiffness.	Palmaris longus	Metal	1. Intact UCL	1. IST failure load of 95% of intact UCL. 2. intact UCL sig. greater stiffness than IST.
Armstrong et al[3]	2005	1. failure load 2. cycles	Palmaris longus	Metal	1. figure-of-8 2. docking 3. endobutton	1. docking sig. greater failure load than IST. 2. no sig. difference in cycles between IST and other techniques.
Furukawa et al[15]	2007	1. failure load 2. cycles	Palmaris longus	Metal	1. docking	1. no sig. difference for failure load. 2. no sig. difference in number of cycles
Large et al[21]	2007	1. stiffness 2. work to achieve 10º ang	Hamstring allograft	Metal	1. intact UCL 2. figure-of-8	1. intact UCL sig. greater stiffness than IST. 2. sig. more work in figure-of-8 compared to IST.
McAdams et al[23]	2007	1. cyclic failure number 2. valgus angle opening	Palmaris longus	Bioabs	1. intact UCL 2. docking	1. no sig difference in number of cycles. 2. at cycle 10 and 100 sig. more valgus opening of docking compared to IST. 3. at cycle 1000 sig. more valgus opening of docking and IST compared to intact

Ang, angular displacement; bioabs, bioabsorbable; IST, Interference Screw Technique; sig., significant; * comparison with Graftjacket as graft is not presented since it has not been used in clinical studies.

replacement by normal bone was not seen in any case. In this study there were no complications related to the triceps tendon graft. The use of a triceps fascia autograft for reconstructions around the elbow was first described by Olsen et al in 2003[25]. The use of triceps tendon fascia autograft overcomes the problem of patients with an absent palmaris longus tendon. As previous mentioned this problem might occur in up to 37.5% of patients and it is suggested that this tendon might be even disappearing in humans[12]. Biomechanical studies evaluating tendon property found failure load of 706 N for the triceps fascia, which exceed the palmaris longus (357 N) and the anterior band of the MUCL (260 N)[4, 27, 31]. This indicates that a triceps tendon autograft is able to withstand sufficient forces when used to reconstruct the MUCL. Furthermore the use of triceps autograft has the advantage that it can be harvested by using the same incision. This last advantage also counts for the Flexor Carpi Ulnaris (FCU) aponeurosis autograft. Slulittel et al described a MUCL reconstruction technique using this graft in 12 patients with 3 postoperative complications: one patient with an ulnar nerve hyperesthesia, one patient with a flexion contracture and one patient with residual instability[33]. Unfortunately they did not describe clinical outcome measures or return to sports. The FCU aponeurosis have not been biomechanically tested to our knowledge. It is therefore unknown whether it is strong enough to serve as a MUCL graft. However, it is an interesting graft source and deserves further investigation to its clinical usefulness. This cohort of patients had a relatively high percentage of athletes that had quit their sport activities, even after a successful 'come-back' after surgery, without elbow complaints. One possible explanation is that most athletes in this study did not play at a professional level and did therefore not financially depend on their sport performances. The surgeon, treating European athletes, should be aware of this phenomena, since the rehabilitation after MUCL reconstruction is long, and the time of successful playing after reconstruction, in this specific group of European athletes is short. This phenomena should be taken into consideration in the decision to advice an MUCL reconstruction in all European athletes. All European surgeons and athletes should be aware that the indication for and results after MUCL surgery are not comparable to those in American and Asian reports. In previous reports was 99% of the MUCL reconstructions done on male patients[35]. Male patients represent with 35% a minority in this study. However, amongst the patients that quitted sports there were three male and three female patients. Thus 43% of the male and 23% of the female patients gave up sports activities. The relatively high amount of patients that quit sports seems to be unrelated to the male-female distribution in this cohort. Another point of interest is the wide variety of sports practiced in this study, with throwing sports accounting for 55% (11 patients). In this subgroup of throwing athletes, one patient stopped within one year because of persistent posterior impingement and two patients stopped after 2.5 and 3 years because of financial reasons and low back pain. The good results in this varied population may not guarantee good results in pitchers and other high demanding overhead athletes. The current study has several limitations. First, with 20 patients included, the sample size is small and the surgeon performed just around 3 MUCL reconstructions each year. Secondly, it is a retrospective analysis, not comparing different techniques. Thirdly, the MEPI score primarily focus on elbow function during daily life activities and not on sport activities. The Conway score describes the level to which the patient returns in sports, but lacks in patient reported outcome and may therefore report a discrepancy between the actual result of the reconstruction and postoperative level of sports. Unfortunately were patient reported outcome measures such as the sport-DASH and Andrews-Carson elbow outcome score not validated for Dutch practice in 2001. This is the first clinical outcome study to evaluate the bioabsorbable interference screw and a triceps tendon fascia autograft for MUCL reconstructions. Although the number of patients included is limited, good results were obtained in most cases with good postoperative MEPI scores and with clinically stable MUCL.

Conclusion

Triceps fascia can be used for MUCL reconstruction as an alternative graft for the palmaris longus tendon. The interference screw technique is a simple and safe technique to restore valgus stability in the elbow. The technique and graft should be further evaluated for its use in high-level pitchers or overhead sports performers. The drop out, even after successful reconstruction, in European athletes is high and should be taken into account during the decision making for MUCL surgery.

Figure 1

Triceps fascia graft prepared with Mercilene stitches.

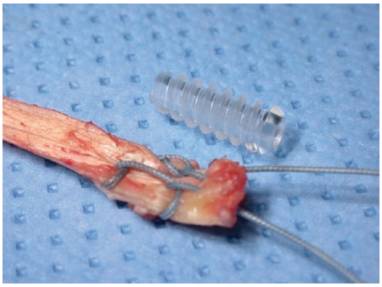

Figure 2

Triceps fascia graft and a bio-absorbable interference screw in detail.

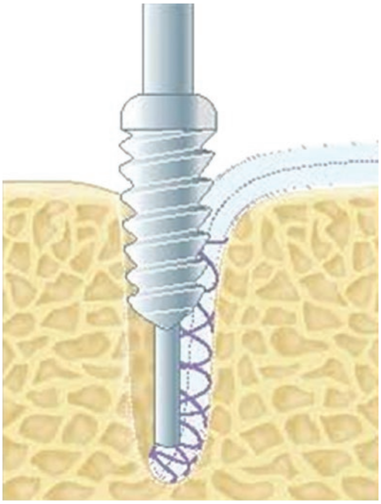

Figure 3

Graft fixation by a bioabsorbable interference screw.

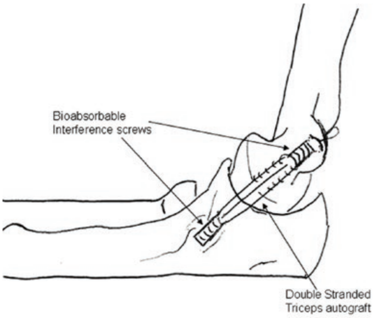

Figure 4

Reconstruction overview of the MUCL with a triceps fascia autograft fixated in the humerus and ulna by 2 bioabsorbable interference screws.

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Chapter 9

General discussion.

The elbow is one of the most complex joints in the human body. It has a high intrinsic stability in combination with a wide range of motion of 150 degrees flexion and extension and a 160 degrees range of motion in pronation and supination. The elbow joint is a common site of injury in the overhead athlete because of the repetitive microtraumatic injuries observed during throwing. Treatment of the athletes elbow is a challenging activity. It must start with taking a thorough history of the complaints. A meticulous physical examination is mandatory. In this a good inspection and detailed examination of the axis of the elbow is very important. A thorough examination of the lateral, medial and posterior aspect of the elbow can reveal several signs which can lead to a proper diagnosis. Diagnostic imaging of the elbow starts with proper X-rays with occasionally an axial olecranon X-ray to detect osteophytes in or at the olecranon fossa causing posterior impingement. Also oblique radial head views can be helpful in detecting pathology of the radial head. Dynamic X-rays are rarely needed, but in case of varus or valgus instability, they can be very helpful. Ct-scans are of additional value in case of loose bodies or posttraumatic deformities. Arthrography can provide some additional information in the case of non-ossified loose bodies or damage to the cartilage. Arthrography is preferably combined with an MRI-scan. MRI is the examination of choice to evaluate the cartilage, the tendons and synovium. Finally ultrasound examination can be a useful tool to evaluate the elbow. On the other hand, it is operator dependent and time consuming. If surgery of the elbow is needed, it must be done by an experienced elbow surgeon who has familiarity with the elbow. Rehabilitation of the elbow, whether post-injury or postsurgical, must follow a progressive and sequential order to ensure that healing tissues are not overstressed. A rehabilitation program that limits immobilization, achieves full ROM as early as possible, progressively restores strength and neuromuscular control, and gradually incorporates sport specific activities is essential to successfully return the athlete to the previous level of competition as quickly and safely as possible.

Chapter 10

Summary and Conclusions.

In the different chapters we have seen that treatment of the athletes elbow is a complex part of the daily routine of the orthopaedic practice. The incidence of pathology around the elbow is rare, and the delay between onset of symptoms and final treatment plan, is long. Treatment of injuries of the elbow in athletes is preferably done in a multidisciplinary setting of a sports doctor, physiotherapist and an experienced orthopaedic surgeon. **Chapter 2** gave an insight in the complexity of the elbow of tennis players. Elbow injuries constitute a sizeable percentage of tennis injuries. A basic understanding of biomechanics of tennis and analysis of the forces, loads and motions of the elbow during tennis will improve the understanding of the pathophysiology of these injuries. All different strokes in tennis have a different repetitive biomechanical nature that can result in tennis-related injuries. In **chapter 3** we conclude that the frequently used NSAID's in muscle injuries are not as beneficiary as we have always thought. Complications of NSAID's are well understood. They compose of interactions with cardiologic and/or pulmonary medication, bowel discomfort and even gastro-intestinal ulcera and bleedings. In this project the effects of non-steroidal anti-inflammatory drugs seemed no different than the effects of an analgesic (acetaminophen) without anti-inflammatory action in an experimental, acute muscle contusion model in mice. Our advice in an acute muscle contusion, is to give adequate pain relief with acetaminophen in combination with physical therapy. In severe cases NSAID's can be used. In **chapter 4** the data between the classic lateral approach for injecting into the elbow, are compared to the forgotten transtriceps approach. There are several techniques for injecting and most doctors inject via the 'classic' lateral 'soft spot'; the triangle between capitellum, radial head and olecranon tip. With this technique there is a risk of damaging the cartilage of the capitellum and/or radial head. Also the lateral approach can compromise the evaluation of an MRI, especially the evaluation of the LCL complex, if there is any contrast leakage. The transtriceps posterior approach can facilitate the interpretation of the MRI and thus result in the correct diagnosis. There is less risk in damaging the cartilage of the elbow. Our study evaluated the technical feasibility of the lesser performed posterior transtriceps approach with MR arthrography and compared it with the classic lateral radiocapitellar approach. In our study contrast leakage occurred in 12 radiocapitellar approaches, which caused a diagnostic dilemma in one subject. There was only minimal amount of contrast leakage in 5 subjects using the transtriceps approach and no diagnostic dilemmas occurred. Results show no significant differences between the approaches. No complications occurred in the posterior transtriceps group . We therefore can conclude that the posterior transtriceps approach is a technical feasible procedure, is easy to perform and avoids a diagnostic dilemma in presumed injuries to the lateral collateral ligament complex. Our results showed a tendency of even fewer amount of contrast leakage, further promoting a more widespread usage of the posterior transtriceps approach. In **chapter 5** general recommendations were given for a standard arthroscopy of the elbow. The technique of arthroscopic surgery has been improved in the last ten years. The incidence of complications as neurovascular damage is acceptable but still high. The most common complication after elbow arthroscopy is neurologic deficit especially of the ulnar nerve. Also post-operative elbow stiffness, persistent portal drainage and infection have been mentioned. Many authors have shown different percentages of complications varying from 0 % tot even as much as 15%. Arthroscopy of the elbow was first described by Burman in 1931. In this first article about arthroscopy of the elbow in the Journal of Bone and Joint Surgery, he concluded that the elbow joint was not suitable for arthroscopy; the joint was too small and the neurovascular structures in the anterior compartment of the elbow were close. In 1932, within one year of the original article, he revised that original article with some technical modifications and slowly arthroscopy of the elbow was performed more often. In the late 1980's arthroscopic surgery of the elbow became more and more popular. **Chapter 6 and 7** delineate specific topics that can be addressed with arthroscopy of the elbow. Posterior impingement and osteochondritis dissecans of the radialhead and/or the capitellum can be treated by arthroscopy with good overall outcome. In **chapter 6** an arthroscopy was done in 16 consecutive elbows with posterior impingement. An arthroscopic debridement of the posterior fossa of the elbow was performed. All patients were evaluated pre- and post-operatively. The average flexion increased from 138º to 140º. The extension deficit of 8º pre-operatively increased to a deficit of average 2º. The MAESS increased from average pre-operative to excellent post-operative. The average VAS in rest decreased from 3 to 0 and during sporting activities the VAS decreased from 7 to 2. Because of this we concluded that arthroscopic debridement of the posterior fossa in athletes with posterior impingement is a procedure that showed excellent midterm results and can therefore be recommended. In **chapter 7** the same kind of project was done only in patients with an OCD-lesion of the radialhead and/or the capitellum. The function of the elbow improved from poor to excellent by doing a standard arthroscopy of the elbow and debridement of the lesion. OCD-lesions are frequently related to sportive activities. Pain is the most presented complaint. Ultimately it can result in loss of range of movement; sometimes in combination with locking. Treatment is dependent on the size and classification of the lesion. Treatment options include debridement or an attempt at refixation of the lesion. In this study it was determined that the clinical outcome of arthroscopic debridement for OCD of the elbow shows good to excellent midterm results. There were no complications. Although the range of motion did not improve significantly, the average MAESS improved. Also pain decreased and all patients were able to go back to work 3 months after surgery. 80% of all patients were able to resume their pre-injury level of sportive activities. **Chapter 8** describes the long term results after an MCL reconstruction with the interference screw fixation and triceps fascia autograft. Evidence that supports the use of this technique are mainly from controlled laboratory studies. The purpose was to evaluate the interference screw technique for MCL reconstructions in a European, clinical setting, with a triceps tendon fascia autograft. 20 consecutive athletes with diagnosed MCL insufficiency that underwent a MCL reconstruction using the interference screw technique were retrospectively reviewed. Indications for reconstruction were medial elbow pain and/or instability caused by insufficiency of the MCL that prevented the athlete from sport activity after a minimum of 3 months of conservative treatment. At a mean follow up of 55 months the mean MEPI score improved from 82 to 91 points. In the end, six patients quitted the sport activities they were preoperatively participating in, all because of reasons unrelated to the MCL reconstruction. There was an excellent result on the Conway scale in 18 patients. Good results are reported based on the postoperative MEPI and Conway score with clinically stable MCL reconstructions without signs of break out or fractures on radiographic follow-up. However, the dropout, even after successful reconstruction in European athletes is high. This should be discussed with every athlete, planned for MCL reconstruction.

Conclusion

- The athletes elbow is a complex entity : Treatment is preferably done in a multidisciplinary setting of sports doctor, physiotherapist and an experienced orthopaedic surgeon. Proper understanding of the basic anatomy and biomechanics of the elbow is mandatory in the treatment of sports-related elbow injuries.
- Standard use of NSAID's in a muscle contusion can create complications that would be avoided with the use of acetaminophen.
- Injection of the elbow can be performed relatively easy, and safely, through the transtriceps approach
- Arthroscopy of the elbow:
    1. is a safe procedure if done by an experienced orthopedic surgeon, but complication rate is higher than in other joints as knee and shoulder
    2. Is becoming more popular because of the increasing interest in overhead sports and thus the increasing amount of injuries in athletes.
- Several pathologic conditions in the athletes elbow as impingment and OCD can be treated successfully by an arthroscopic procedure.
- Reconstructing the MCL can be done by an autograft triceps graft and interference screw, but even after a successful reconstruction, the drop out of European athletes is high.

Chapter 11

Samenvatting en conclusies.

In de verschillende hoofdstukken hebben we gezien dat het behandelen van een atleet zijn elleboog een complexe taak is in de dagelijkse praktijk van de orthopedisch chirurg. De incidentie van de verschillende aandoeningen rond deze elleboog is laag en daardoor is er vaak een vertraging van het uiteindelijke behandelplan. De behandeling van de atleten elleboog gebeurd bij voorkeur in een multidisciplinaire setting door een sportarts, sport fysiotherapeut en een orthopedisch chirurg die veel ervaring heeft met de verschillende afwijkingen die kunnen optreden. In **hoofdstuk 2** wordt de complexiteit van de elleboog bij de tennisspeler onder de loep genomen. Elleboog letsels bij tennisspelers komen veelvuldig voor. Een goed inzicht in de biomechanica van de elleboog en een goed begrip van de krachten over de elleboog tijdens het tennis spel zorgen ervoor dat er een beter begrip is voor de afwijkingen die kunnen ontstaan in de elleboog van een tennis speler. Tennis gerelateerde letsels ontstaan al snel bij de verschillende slagen tijdens het tennis spel. **Hoofdstuk 3** laat zien dat de veelal veelvuldig gebruikte NSAID's, eerder een grotere kans geven op complicaties dan dat ze een gunstig effect hebben op de spierheling. Complicaties van NSAID's zijn uitgebreid gekend en gedocumenteerd. Recent wordt veelvuldig gewaarschuwd voor de interactie met cardiologische en/of pulmonaire medicatie. Ook gastro-intestinale bijwerkingen komen veelvuldig voor. Deze kunnen variëren van het optreden van maagzuur tot de veel ernstigere maagbloedingen of dunnedarm afwijkingen. In het onderzoek gepresenteerd in hoofdstuk 3 blijkt dat het gebruik van NSAID's bij acute spierblessures in een experimenteel diermodel geen gunstigere effecten heeft in vergelijking met paracetamol. Ons advies is dan ook om acute spier blessures te behandelen met adequate pijnstilling in de vorm van paracetamol in combinatie met in beweging blijven middels fysiotherapeutische begeleiding. In de ernstigere gevallen kan men natuurlijk wel NSAID's gebruiken om een extra pijnstillend effect te geven. In **hoofdstuk 4** keken we naar de effectiviteit van 2 verschillende technieken van intra-articulaire injecties van het elleboogsgewricht. De klassieke laterale benadering versus de nieuwere transtriceps benadering. De meeste artsen injecteren via de klassieke laterale benadering tussen de radiuskop, olecranontip en de laterale humerus epicondyl. Met deze techniek is er een risico op beschadiging van het kraakbeen van de radiuskop en/of van het capitellum. Verder kan de beoordeling van de MRI, in het bijzonder het laterale bandcomplex van de elleboog, bemoeilijkt worden door eventuele contrastlekkage. Met de transtriceps benadering worden deze laatste twee complicaties vermeden. Ons onderzoek evalueerde de technische haalbaarheid van de transtriceps benadering voor intra-articulaire contrast injecties en de beoordeelbaarheid van de MRI, in vergelijking met de klassieke laterale benadering. In ons onderzoek waren er 12 contrast lekkages bij de radiocapitellaire benadering, bij 1 gaf dit problemen met de beoordeelbaarheid van de MRI. In de 5 transtriceps benaderingen gaf de lekkage geen problemen met de beoordeelbaarheid van de MRI. Er was minimale tot geen contrast lekkage. Er waren geen complicaties bij de beide benaderingen. We kunnen daarom concluderen dat de transtriceps benadering voor intra-articulaire injecties een technisch goede techniek is, welke makkelijk uitvoerbaar is en geen dilemma's geeft bij de beoordeling van de MRI. In **hoofdstuk 5** werd een overzicht gegeven van de arthroscopie van de elleboog in het algemeen. De techniek is de laatste 10 jaar verbeterd. De incidentie van voornamelijk nervus ulnaris letsels in dramatisch gedaald, maar nog steeds geen 0%. Andere complicaties die kunnen optreden na een elleboogsarthroscopie zijn een post-operatieve stijve elleboog, persisterende portal lekkage en infecties van de portals dan wel van de elleboog zelf. Meerdere auteurs laten verschillende percentages zien van complicaties na een elleboogsarthroscopie, variërend van 0-15%. De arthroscopie van de elleboog werd als eerste beschreven door collega Burman in 1931. Hij concludeerde dat het elleboogsgewricht niet geschikt was voor arthroscopie; het gewricht is te klein en de neurovascullaire structuren met name aan de voorzijde liggen te dichtbij. In 1932 echter, binnen 1 jaar na het verschijnen van zijn originele artikel, reviseerde hij zijn eerdere conclusie en langzamerhand werden er sindsdien steeds meer elleboog arthroscopieen gedaan. **Hoofdstuk 6 en 7** beschrijven 2 specifieke elleboogsaandoeningen welke sport gerelateerd zijn en goed met een arthroscopie van de elleboog aangepakt kunnen worden. Posterieure impingement van de elleboog en een osteochondritis dissecans van de radiuskop en/of het capittellum kunnen beide met goede resultaten scopische behandeld worden. In **hoofdstuk 6** worden de resultaten gepresenteerd van 16 ellebogen met posterieure impingement. Er werd een scopische debridement gedaan van de posterieure fossa van de elleboog. Alle patiënten werden pre- en postoperatief gescoord. De gemiddelde flexie nam toe van 138° naar 140°. De extensie beperking nam af van 8° naar 2° gemiddeld. De MAESS nam toe van gemiddeld pre-opartief naar excellent post-operatief. De gemiddelde VAS in rust nam af van 3 naar 0 en gedurende sport nam deze af van 7 naar 2. Uit bovenstaande valt te concluderen dat een arthroscopische debridement van de posterieure fossa van de elleboog bij posterieure impingement een goede behandelingsmethode is voor deze aandoening. In **hoofdstuk 7** wordt een zelfde onderzoek beschreven. Hierbij werd een OCD-haard van het capitellum en/of radiuskop arhtroscopisch genettoyeerd. De functie van de elleboog verbeterde van slecht naar excellent. De klachten van een OD-haard zijn vaak sport gerelateerd. Pijn en verlies van functie, soms in combinatie met slotsensaties zijn de meest gepresenteerde klachten. De behandeling is afhankelijk van de plaats en de grootte van het defect. De behandelingsopties zijn nettoyage van het defect of soms met een poging tot refixatie van de kraakbeen flap. In deze studie werd geconcludeerd dat een arthroscopische nettoyage van het defect goede resultaten liet zien op de middenlange termijn. Er waren geen complicaties. De gemiddelde beweging verbeterde niet significant, maar de pijn en de gemiddelde MEASS verbeterden beide wel significant. 80% van de patiënten kon na 3 maanden hun sport weer bedrijven op een niveau van dat voor het letsel. **Hoofdstuk 8** beschrijft de lange termijn resultaten van een MCL reconstructie met autologe tricepspees graft en interferentie schroef fixatie. Het gebruik van deze techniek was tevoren eigenlijk alleen maar op cadavers getest. Wij onderzochten 20 opeenvolgende patiënten die met deze techniek behandeld zijn. Ze werden retrospectief nagekeken. Indicaties voor de MCL reconstructie waren pijn en instabiliteit welke de atleet weerhield om te sporten, dit wel na een periode van 3 maanden rust. Bij een gemiddelde follow up van 55 maanden verbeterde de gemiddelde MEPI score van 82 naar 91 punten. Uiteindelijk waren 6 atleten gestopt met hun sport, niet gerelateerd aan de MCL reconstructie. Er was een excellent resultaat bij de CONWAY schaal in 18 patiënten. Er waren goede resultaten gebaseerd op de postoperatieve MEPI en CONWAY schaal. Zelfs na een succesvolle MCL reconstructie is de postoperatieve uitval van patiënten die hun sport nog kunnen bedrijven erg hoog. Dit moet pre-operatief dan ook goed met hen besproken worden.

Conclusie

- De atleten elleboog is een complex geheel; de behandeling ervan wordt bij voorkeur gedaan in een multidisciplinair team van sportarts, fysiotherapeut en een orthopedisch chirurg met veel ervaring op het gebied van de elleboog. Een goed begrip van de anatomie, biomechanica en pathofysiologie van de atleten elleboog is van groot belang voor de uitkomst van de behandeling
- Routinematig gebruik van NSAID's bij spierblessures kan complicaties geven die bij het gebruik van paracetamol te vermijden waren geweest.
- Arthroscopie van de elleboog:
  1. Is veilig tenzij verricht door een orthopedisch chirurg met veel ervaring. De complicatie kans is echter veel hoger in vergelijking tot arthroscopieen van andere gewrichten
  2. Begint steeds populairder te worden naar mate er meer bovenhandse (werp-) sporten gedaan worden.
- Een intra-articulaire injectie in het elleboogsgewricht kan relatief eenvoudig en veilig gegeven worden via de transstriceps benadering
- Sommige specifieke aandoeningen van de atleten elleboog zoals posterieur impingement en OCD-haarden kunnen het best arthroscopisch behandeld worden.
- Reconstructies van het MCL van de elleboog kunnen gedaan worden met een triceps autograft en interferentie schroef fixatie. Er is echter een gerede kans dat het pre-operatieve niveau van sport echter niet meer gehaald word.

Chapter 12

Curriculum Vitae & Dankwoord.

Frank Theodoor Gabriel werd geboren op 4 februari 1973, te Eindhoven. Tijdens zijn jeugd werd veel in het buitenland verbleven; met name in de Verenigde Staten. Uiteindelijk werd de basisschool afgerond op de internationale school in Eindhoven. Na de basisschool werd gestart op het gymnasium en via een ommezwaai naar de HAVO uiteindelijk toch het diploma VWO behaald aan het Lorentz lyceum te Eindhoven. De studie geneeskunde werd gevolgd aan de Rijksuniversiteit van Maastricht van 1992 t/m 1999. Na het basisarts diploma startte hij als AGNIO orthopedie-chirurgie in het oude St. Joseph ziekenhuis te Veldhoven, thans Maxima medisch centrum. Hier heeft hij 1 jaar gewerkt en vervolgens heeft hij een praktijk en wetenschapsstage gedaan aan de University of North Carolina, Chapel Hill, USA onder leiding van Professor Dr. L.C. Almekinders. Alhier werd de basis gelegd voor de rest van zijn opleiding en interesse in de orthopedische chirurgie en sport gerelateerde letsels van het steun- en bewegingsapparaat. Na terugkomst uit de USA heeft hij nog even gewerkt als AGNIO in het St. Laurentius Ziekenhuis Roermond, maar al snel kon begonnen worden met de opleiding tot orthopedisch chirurg in de regio Oost met als moeder kliniek de St. Maartenskliniek te Nijmegen onder leiding van Dr. A.B. Wymenga. De vooropleiding werd voltooid in het Maxima Medisch centrum onder leiding van Dr. F.A.A.M. Croiset van Uchelen. Direct na zijn opleiding is hij even chef de clinique geweest in het Diakonessenhuis te Utrecht. Sinds oktober 2008 is Frank werkzaam als orthopedisch chirurg in het SJG Weert te Weert. Hij woont in Leende met zijn partner Marije en hun 3 kinderen Thijmen-Olivier, Frederieke en Merijn.

Dankwoord

Chronologisch in het leven

Mamma

Vooral dankzij jouw oeverloze geduld en avonden aan de kamertafel ben ik uiteindelijk geneeskunde gaan studeren. Even leek het erop dat er uitgeweken moest worden naar België, maar dankzij een door jou geïnitieerde hardheidsclausule werd ik alsnog nageplaatst in Maastricht voor de studie geneeskunde. Ook gedurende de studententijd en gedurende mijn opleiding orthopedie was je altijd “thuis” om met je ongekende kennis van de Engelse taal mij bij te staan. Mamma je bent mijn steunpilaar geweest. Altijd en eeuwig

Pappa

Je eeuwige kritiek heeft me hard gemaakt en dit heeft mij een heel eind de goede weg op geholpen. Dank voor al het vertrouwen. Kijk nu maar eens wat je zoon voor elkaar heeft gekregen.

Broers

Pieter en Mark, jullie zijn mijn broers. Wij zijn de Daltons. Altijd geweest. Samen sterk door dik en dun.

Dr. F.A.A.M. Croiset van Uchelen

Fred, de initiator van ‘mijn dokter zijn’. De vader van mijn beste vriend. Tegen jou keek ik altijd op. De vooropleiding heb ik bij jou gevolgd; ‘de natte handdoek in de nek’ of ‘de grote groene stift door aantekeningen in de status’ als er iets niet goed ingevuld was. Wat heb ik veel van jou geleerd over de sociale omgang met patiënten! Ik neem nu ook mijn kinderen in het weekend mee naar het ziekenhuis om te kijken hoe het met de patiënt gaat. Dankzij jou zie ik mijn patiënten niet als patiënten. Het zijn mensen met een naam, met een hart en met gevoel.

Dr. J.B.A. van Mourik

Jan, bij jou mocht ik proeven aan de orthopedie. Bij jou heb ik mogen voelen hoe het is om mensen weer op de been te helpen. Bij jou heb ik geleerd dat conservatieve fractuur behandeling een goede optie is. Dank voor je inleiding in de orthopedie. Op een dag vroeg ik je wat ik moest doen om een opleidingsplek te bemachtigen. Je belde toen meteen naar collega Almekinders. Ik had niet gedacht dat ik 9 dagen later in de USA zou landen. Dit heeft zeker meegespeeld in het verkrijgen van een opleidingsplek.

Ook dank aan al de collega's in mijn ANGIO tijd; collegae A.J.G. Nollen, H.A.G.M. Sala, dr. T.E. Lim en P.A.M. Winkelman †.

Professor Almekinders

Near the end of the year 1999 Jan van Mourik called you that there was a resident that was interested in doing a research project abroad. Your answer was simple:' When can he arrive?'.. And 9 days later I took a plane to North Carolina, Chapell Hill. I stayed for 3 months and this has resulted in 2 major articles in pear reviewed journals, a presentation at the AOSSM in 2000 in Florida and finally chapter 3 of my thesis. Many thanks to you and your wife for having me. Because of my scientific work under your inspiring supervision, I finally managed to become an orthopedic resident.

Dr. A.B. Wymenga

Mijn opleider; de echte orthopeed die mij secuur en netjes heeft leren werken. Even hard, even strikt, maar aan het einde de man die je nodig hebt om je opleiding tot een goed eind te brengen. Ate; je woorden "niet lullen maar poetsen" gebruik ik dagelijks om de gang er in te houden. Dank voor alles in mijn opleiding. "Soms besef je pas later wat je aan iemand hebt gehad".

Drs. K. De Foort en Drs. D.B. van der Schaaf

Jullie zijn de begeleiders geweest van mijn laatste opleidingsjaar. Van jullie heb ik echt leren opereren. Dit heeft mij zeker gemaakt en stelt mij nu in staat om niet te twijfelen en te geloven in hetgeen ik kan. Het is immers uitermate belangrijk in het laatste jaar van de opleiding, om dit zelfvertrouwen te creëren. Dank daarvoor, want dat is niet uit een leerboek te leren.

Dr. D Eygendaal

'mevrouw de elleboog specialist'. Bij jou ben ik het eerste jaar van mijn opleiding begonnen. Ik was meteen gek op je en op alles wat je kon. Krachtig, zeker, kundig, oprecht en menselijk. Jij hebt altijd geloofd in mij, en had vertrouwen dat ik dat 'boekje' tot een goed eind zou brengen. En zie hier, daar is ie dan.' Top wijffie', dat ben je.

Professor dr. R.L. Dierks

Tja professor, dat was even schrikken toen het proefschrift 'ineens' klaar was. U had dit wellicht niet meer verwacht, of toch wel?. Toch ben ik U eeuwig dankbaar voor al die jaren dat U geduldig heeft gewacht op mij. Ik wilde een proefschrift met gepubliceerde artikelen. Niet met 2 in press en met 2 in review. Nee gewoon met 7 gepubliceerde artikelen. Hier is het dan. In de laatste maanden heeft U mij flink geholpen met de laatste details. U was altijd bereikbaar voor overleg. Dank, veel dank.

Collegae; Armin, Menno en Wilmar

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Oud Collega Schlösser

Ton, je belde me om waar te nemen in Weert en Weert heeft me daarna nooit meer los gelaten. Je had me beloofd, na mijn waarneming, dat je me zou bellen als er een vacature gestart zou worden. Binnen 1 dag vielen alle puzzelstukjes bijeen, en 1 maand later startte ik bij jou in Weert. Je hebt me fijn bijgestaan bij grote operaties en hebt me de kneepjes van het management vak geleerd. Ook leerde je mij hoe om te gaan met managers en met bestuur. Dank. Veel dank. Ook voor je steun als paranimf.

Collega dr. J.A. van Essen

Jeroen, ik leerde je kennen in Arnhem tijdens onze opleiding. Een Rotterdammer met een grote mond maar met het hart op de goede plek. Toen ik in Weert startte was ik blij dat jij daar ook werkte. Samen hebben we een mooie club, waar we vaak met z'n tweede in de dienst opereren. Dat is altijd even professioneel en samen de ok op stelten zetten is altijd leuk. Je hebt me enorm gesteund bij mijn proefschrift. Zowel tekstueel als opbeurend. Als paranimf stond je altijd klaar voor overleg. Nog vele jaren te gaan in dit gesticht dat ziekenhuis heet. Je bent en blijft een aparte vent met je roze schoenen tijdens de mamma-week en met je huis-kapper in Rotterdam.

Marije en kinderen; Last but always up front

En dan mijn alles in dit leven, mijn schat die ik hoog boven op de berg tegen ben gekomen. Een donkere wolk, met één zonnestraal die op jou gezicht scheen. Ik zag je die dag vanuit de skilift en ik dacht toen echt: "dat zou d'r wel eens kunnen zijn". Een avond in de apres ski-bar en kijk nu; Samen kregen we Thijmen-Olivier, Frederieke en Merijn. Het is niet makkelijk voor je geweest. Al die avonden en vrije dagen die in dit boekje zitten. Altijd maar alleen met de kinderen en alles zelf doen. Ik heb je nog gezegd dat ik een druk baasje ben. Dat zal denk ik niet veranderen. Maar je neemt me zoals ik ben. We hebben een mooie toekomst voor de boeg en ik hou ziels veel van je en van onze 'super aapies'. Je bent mijn alles, samen met de kinderen.